

**TRANSACTIONS**  
**of the**  
**NATIONAL ACADEMY OF SCIENCE**  
**AND TECHNOLOGY, PHILIPPINES**

1996  
Volume XVIII



Republic of the Philippines  
National Academy of Science and Technology, Philippines  
Philippine Science Heritage Center, DOST Complex  
Bicutan, Taguig, 1631 Metro Manila

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**18th ANNUAL SCIENTIFIC MEETING  
1996**

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**NATIONAL ACADEMY OF SCIENCE AND TECHNOLOGY  
18<sup>TH</sup> ANNUAL SCIENTIFIC MEETING  
Insular Century Hotel, Lanang  
8000 Davao City  
10-11 July 1996**

**WELCOME ADDRESS**

**CONRADO S. DAYRIT, M.D.**

*President, National Academy of Science and Technology  
Bicutan, Taguig, 1631 Metro Manila*

My Fellow Academicians, my Fellow Workers in Science, the Very Reverend Invocators, Ladies and Gentlemen, Friends. In behalf of the Academy and its Members, the Academicians, I welcome you all to this 18th Academy Meeting.

This is, as our Secretary has mentioned, the first time that we bring these meetings out of Manila, and this year we selected Mindanao, to discuss how science and technology can be made to contribute more effectively towards a more dynamic Mindanao. Not that Mindanao has not been dynamic. The importance of Mindanao to the Philippines has long been recognized as the Land of Promise.

I remember that when we graduated from the Ateneo, some of my classmates and friends were enticed to come to Mindanao to homestead by President Quezon himself and they established their farms here. That was way back in the 1940s. But, it must be admitted that of the three principal regions of the Philippines, Mindanao has always played not second, but third fiddle to Luzon and the Visayas. Now this must change.

The Philippines cannot afford to ignore this big island and its people anymore. And the best way for Mindanao to catch up is, we think, through science and technology. We are here therefore, gathered together this morning with the scientists, industrialists, academicians, and science workers of this island to discuss how this land, these resources, the industries here can be improved, maximized; how her manpower can be developed; and how her health and environmental problems can be resolved. We will want to know how science and technology can best be applied and used to bring all these about. Realizing full well that only by full cooperation and



coordination at the national level can there be lasting success, prosperity, and peace with understanding. The peace talks between the government and the Mindanao National Liberation people must go on to start the peace and then science and technology can have a chance to take over. How do you say this can be brought about by science and technology? How can they improve this situation?

One of my favorite Aesop fables is the contest between the wind and the sun as to who could remove a man's coat from him. So the wind blew and blew and blew and blew until it was blue in the face but the man just held onto this coat, held it tighter until the wind just gave up. The sun merely smiled, turned his rays on the man, and the man started to feel warmer, fanned himself more vigorously, and when he started perspiring, he removed his own coat. The sun didn't do it; it was the man who did it himself. This is the big difference I can see between force, which often fails, and the environmental changes brought about by science and technology whose effects, although more subtle, are certainly more effective. Thus may science and technology improve the situation here in Mindanao.

Well, I hope that all of us will have a very worthwhile and fruitful stay in the City of Davao and relish the hospitality here and learn from this interchange between our scientists and our industrialists and our health workers and all who are interested in the future of Mindanao. Again, welcome to all.

Thank you.

## **KEYNOTE ADDRESS**

**LOURDES S. ADRIANO, Ph.D.**

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### **INTRODUCTION**

Foremost of all, Mr. Paul G. Dominguez sends his deepest regrets for not having been able to make it today. Working for more than 25 hours per day since 1992 has, I think, taken its toll on his health. He is fine but his doctors have advised him to complete the prescribed two-week rest before going back to work.

It is a great pleasure and honor for me to welcome you to Mindanao and to Davao City. I hope the amenities of this bustling city of Mindanao gave you enough rest and sleep last night as you are about to tackle a series of substantive issues relating to science and technology and their implications on the island's development.

On behalf of the Mindanaoans, I would like to extend our deepest gratitude to the management and members of the National Academy of Science and Technology for having chosen "Science and Technology for a More Dynamic Mindanao" as the theme for its 18th annual scientific meeting.

Mindanao today is undergoing profound changes in its role in the nation, and because the community is at a crossroads, the unfolding of events over the next few years will chart the strategic direction of Mindanao's development.

### **MINDANAO'S PAST: VICIOUS CYCLE OF UNDERDEVELOPMENT**

Only a decade ago, Mindanao was the epitome of underdevelopment. Despite its huge resource advantages Mindanao's economy has been continually trapped in a vicious cycle of underdevelopment. Its periodic lackluster economic performance, exacerbated by high population growth, has resulted in low employment weak purchasing power of the populace, rising number of the poor, and a sluggish economic growth.

Moreover its development path typified a classic case of unsustainable development: destructive and over-exploitation of the island's natural resources monocrop agriculture nestled in vast agribusiness plantations industrial enclaves which led to little technology transfer to the community, and a volatile security situation where insurgency and secessionist groups thrived on the poverty and marginalization of large sectors of the community.

Three major reasons why Mindanao's economy has remained largely stagnant have been cited. These are: (1) its backwater role as a food and raw material supplier to Manila and other urban centers in the country; (2) the regional political divisions which only heightened the fragmented development of the island; and (3) the continuing socio-political discord.

### **A NATIONAL GOVERNMENT PUSH FOR MINDANAO'S DEVELOPMENT**

In recent years, the government has taken a pro-active role in pursuing a high, sustainable, and broad-based growth for Mindanao. Specifically, it has undertaken several initiatives in four key areas: (1) accelerated infrastructure development; (2) the membership of Mindanao in the newly-created growth triangle, BIMP-EAGA; (3) policy reforms; and (4) peace and order.

Mindanao has been a recipient of unprecedented investments in basic infrastructure projects. Just last week the President inaugurated the General Santos International Airport. This airport can handle Boeing 747 aircraft and is sure to boost the tourism and agriculture/fishery sectors of the SOSKSARGEN Growth area which comprise South Cotabato, Sultan Kudarat, Sarangani and Gen. Santos City. Also vital arterial road projects under the Presidential Flagship Program are under construction and are expected to be substantially completed by 1998, thus laying the physical basis for economic growth.

Last week, this city played host to the international meeting of the Senior Officials' and Ministers' meeting of the BIMP-EAGA. This is a project that hopes to intensify economic cooperation between the sub-national economies of Brunei Darussalam, the eastern provinces of Indonesia, the east Malaysian states of Sarawak, Sabah and the Federal Territory of Labuan, and Mindanao and Palawan of the Philippines. The creation of the BIMP-EAGA has resulted in numerous opportunities for farmers, as well as small and medium scale enterprises which constitute the bulk of Mindanao's private sector. More significantly, the growth triangle has served as a catalyst in energizing the Mindanao economy from the economic free-fall of the '80s and its springboard to global competitiveness.

National policy reforms particularly in transportation and telecommunications have resulted in better services to the island, thus ensuring a more effective integration of the Mindanao's producers with the resurgent national economy.

The rice shortage of 1995 in Metro Manila also brought to the fore the strategic role that Mindanao can play in the context of national food security.

Considering that the island generates more than a third of the country's agricultural value added and is the source of 40 percent of the national food trade, Mindanao can become the country's food basket, if only its agricultural sector is given the proper infrastructure, financial, technological, and marketing support.

But what has captured the country's attention is the recent formation of the Southern Philippines Council for Peace and Development (SPCPD). Although it has elicited varying opinions, its formalization has become the opportunity for different sectors in Mindanao to ventilate their positions. It is hoped that from this exercise, a broad-based institutional arrangement and hopefully, a more meaningful, just, and lasting peace accord will ensure.

The convergence of these and many more events in Mindanao form the landscape of the island's present development path and has contributed to its changing development paradigm.

Today, Mindanao is faced with a unique window of opportunity to thrust itself into the 21st century. Both the internal and external conditions are right for the island to change its role from an economic backwater to a zone of peace and development.

### **MINDANAO 2000: BLUEPRINT FOR DEVELOPMENT**

To take full advantage of this opportunity, the community has come out with a 15-year development framework plan called Mindanao 2000. The plan envisions Mindanao to be a vibrant and integrated island-wide economy, led by globally competitive agriculture and agri-industries that will be the basis for industrialization in the 21st century.

The island's transformation into a dynamic economy shall be achieved through a four pronged strategy of export-oriented agricultural development and agri-industrialization, environmental management, and social development. Parallel to these are the four goals of global competitiveness, internal and external integration, sustainability, and people-centered development.

In the pursuit of these goals, a spatial planning framework has been proposed. Specifically, Mindanao has been divided into seven area development zones (ADZs,) where each zone comprises a group of contiguous urban and rural centers which display strong economic and socio-cultural ties. The seven ADZs are: (1) SOSKSARGEN, (2) Davao Gulf, (3) CARAGA, (4) CIC Expanded, (5) Central Mindanao, (6) Panguil Bay-Mt. Malinang Area, and (7) Zamboanga-Sulu.

The ADZs are consolidated into three economic growth clusters. Based on their comparative advantages, the three clusters and their strategic role in Mindanao's development process are: (1) the North Coast which shall serve as the island's Agri-Industrial Corridor and gateway to the domestic market; (2) Southern Mindanao which shall be the Food Triangle and agri-industrial hub to EAGA; and (3) Western Mindanao, projected to become the island's marine center and trading hub for EAGA.

### **BULLISH ECONOMY**

The community has responded favorably to the challenge and opportunities provided by this changing development paradigm, and continuously seeks channels to thrive in this dynamic and competitive environment ushering in the entry into the 21st century.

The Gross Regional Domestic Product of Mindanao has been positive and increasing since 1993. Exports have likewise manifested an upward trend averaging at 24 percent per annum for the years 1992 to 1995. Investments are steadily growing and both local and foreign investors are taking a second look at Mindanao as a viable destination for their investments. Lastly, average family incomes have been on the rise since 1991.

### **CHALLENGE AHEAD: BRIDGING PEACE AND DEVELOPMENT**

Mindanao has still a long way to go if it is to grow in step with the rest of Asia – the fastest growing corner of the world today. The most pressing issue is the two polar perceptions on Mindanao's development. On one hand, the private sector is bullish about the positive growth centers such as CIC, Davao Gulf, SOSKSARGEN, and Zamboanga. On the other hand, the problems of poverty and instability have served as engine brakes to its sustained growth. The principal constraint to development has been the lack of peace.

### **TASK FOR FILIPINO SCIENTISTS AND PROFESSIONALS**

It is within this perspective that I would like to suggest key points which you may want to address during your one-and-a-half-day workshop:

*First*, concerns your role and contribution to accelerating and sustaining agri-industrialization of the island economy in the context of (1) a freer global trading environment, (2) natural resource depletion, and (3) the large poverty situation. Specifically, much of your technical focus has been in influencing the supply or production side without regarding the importance of relating this with internal and external demand. On the supply aspect, the weak areas concern the inadequate provision of and access to appropriate technology by the numerous small-scale producers (lowland and upland farmers as well as fisherfolk). There is still this prevailing assumption within the science community that it is the sole responsibility of the government to provide this technology, R&D, and extension services. With the limited public sector funds, it becomes incumbent on the community to include in their research institutions measures that will enhance private sector participation in the development and extension of technology and technical knowledge.

Moreover, since the land endowments of the country are highly constrained, the generation of technology should be toward those which can be utilized efficiently in small-scale farms; are land-intensive; and are labor-using. Productive and market-related infrastructure should aim for those which enable the producers to become flexible in their crop choices.

In addition, it is high time that we cease looking at the agricultural and fishery sectors in the context of primary production alone but should view these in the larger agribusiness chain.

Lastly, in this age of internet systems, small-scale producers should have equal access to market information. As one famous economist aptly concluded, farmers are efficient but poor, partly because of limited infrastructure facilities and inputs, but also due to their limited access to vital information on production and demand.

*Second*, sustaining Mindanao's initial economic successes requires investment on its labor resource. In a recent examination of top public high school students for science scholarships in college, the Muslim communities garnered the lowest marks. Our own research also showed that these communities received the least health-related facilities and services. What affirmative measures can the government initiate that will effectively and efficiently address these concerns?

Related to this issue is the nature and mode of industrialization that is appropriate for Mindanao. Specifically, what steps should be undertaken so that the small and medium enterprises become globally competitive and at the same time major users of our abundant labor resources? With the limited labor absorption of the agricultural sector, what measures should immediately be undertaken in the context of human resource development that will increase the utilization of labor of the non-agricultural sectors and continually improve the skills of the labor sector?

And *third*, with the rampant conversion of agricultural land to non-agricultural uses, how can a balanced ecosystem be ensured in Mindanao without sacrificing its economic growth?

## CONCLUSION

With these as food for thought, let me leave you to your discussions. I wish you a fruitful meeting. Thank you.



# PLENARY SESSION I “MINDANAO: ITS PEOPLE AND CULTURE”

## Mindanao: Its People and Culture and Their Contribution for a More Dynamic Mindanao

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### INTRODUCTION

*Bismillahi rahman ir raheem.*

First of all, my apology to Dr. Conrado S. Dayrit, President, National Academy of Science and Technology, and Miss Luningning E. Samarita, Executive Director, and the sponsors of this conference for the delay in the submission of this paper in spite of the fact that I was given a deadline (twice) to submit the paper.

*Sabi nga nila, “Ang Pilipino daw ay mahilig sa larong ‘last two minutes’ at dyan binubuhos ang lahat ng kakayahan upang makapunto”.*

The truth is, I was surprised to know that I was given the assignment to read the topic entitled, “Mindanao: Its People and Culture” which is a tall order. Moreover, one has to relate this topic to the theme, “S & T for a More Dynamic Mindanao”. That makes the paper quite difficult to think about and equally difficult to write.

On the other hand however, the delay is done on purpose – to be able to read and read more materials written on the topic so that the paper itself will not appear as a “two-minute” preparation. Up to this moment there are still events unfolding and being written about the “dynamism” of Mindanao that deserve one’s attention and concern not to exclude the issue on the peace process. This is another topic that will certainly need closer study since it has implications basically on the development of Mindanao and the issue of inter-ethnic relations and understanding.



Before pursuing this paper further, we would like to put forward these observations:

1. There are several studies on and about Mindanao from ethnography to policy studies, and more recently on Peace Education/Peace Process that should be collated as data base on Mindanao.
2. There are quite a number of consortia in Mindanao, both GOs and NGOs, with specific concerns and interests that should likewise be collated to form a federation on R & D.
3. Mindanao has a diversity of peoples, religions, political parties, etc. – that need to be coordinated and harnessed for peace and development.
4. Permanent structures (like schools and other institutions) should be established and maintained to pursue the philosophy of sharing and complementation in Mindanao.
5. The people of Mindanao, its culture, and environment are inseparable components in building a more progressive and humane society. The inseparability of these three basic components should be the subject for the establishment of an Institute of Indigenous Knowledge. Details of these points as enumerated constitute the main thrust of this exploratory discourse.

### **Why Was Mindanao Called the “Land of Promise?”**

According to Costello (1992), the original reason for labeling Mindanao as the “land of promise” lay in its potential for offering a rich store of natural resources, especially land, to the rapidly expanding Philippine population. The prospects of acquiring some part of Mindanao's vast tracts of unused land lured millions of migrants to the region during the 20th century. Population grew from 8.8% of the country's total number of inhabitants in 1903 to a full 22.7% as of 1980.

### **Mindanao's Peoples and Population**

According to Rodil (1988) the population of the region can only be broadly classified into two categories: the indigenous and the settlers-based.

1. *Indigenous* – the Islamized native inhabitants of the region is made up of 13 ethno-linguistic groups that constitute approximately 20% of the total regional population. These groups include the Iranun/Illanun, Jama Mapun, Kalagan, Kalibugan, Maguindanaon, Maranao, Molbog or Melebugnon, Palawani, Sama, Sanggil, Tausog, and Yakan. Scholars generally include the Badjao in this grouping but whether they are really Islamized or not is disputed by the local people. It has been noted that some of the Badjao/Bajao are “nominally” Islamized. Further studies on this controversy should be pursued.

2. *The Lumad* (the name is the Bisayan equivalent of native or indigenous; also referred to as highlanders, tribal Filipinos, or cultural communities) – made

up of 21 ethno-linguistic groups constituting approximately 5% of the total regional population. They are the Ata, Bagobo, Banuanon, Batak, B'laan, Bukidnon, Dibabawon, Higaonon, Mamanwa, Mangguwangan, Manobo, Mansaka, Matigsalog, Palawan, Subanen, Tagakaolo, Tagbanua, T'boli, Tiruray, and Ubo.

Other groups like the Tigwa, the Isamal, and the Talaandig are generally regarded as sub-tribes. It is not clear to Rodil (1988), which other groups may be considered as Lumad in Palawan. Twelve of these tribes are native inhabitants of the 13 provinces: Bagobo, Batak, B'laan, Higaonon, Manobo, Palawan, Subanen, Tagakaolo, Tagbanua, T'boli, Tiruray, and Ubo.

3. *Indigenized* – also considered natives of the region but have been totally assimilated into the major culture. In the northern and eastern coasts of Mindanao, they are the Misamisnon, Cagayanon, Camiguinon, Butuanon, Surigaonon, Iliganon, and Davawenon. In Zamboanga, they are the Chabacanos who were brought to the Philippines from Ternate in the Moluccas in 1663, then in Zamboanga in 1718. In Palawan, they are the Kalamianen, Agutaynen, Kagayanen, and Cuyunon.

4. *Settler-Based* – mostly the Christians from Luzon and the Visayas who migrated to the region in the 20th century under the resettlement program of the U.S. colonial government. They and their descendants along with the indigenous group now constitute approximately 75% of the total regional population.

Costello (1992) observed that Mindanao and Sulu together constitute a relatively large and heterogeneous setting geographically and culturally. Generalizations meant to cover the entire region are difficult to make and are, in any event, potentially misleading.

Population data from Mindanao and Sulu are not up-to-date or uniformly accurate. The demographic evidence from Mindanao and Sulu is mixed – people of the region have shown a remarkable ability to adapt to the rapidly changing world in which they find themselves. High levels of mortality found throughout the region – particularly for the Muslims and the tribal groups – have clearly identified this as a major demographic concern.

On the other hand, Magdalena (1995) noted among others the following features of Mindanao's ecosystem and population:

1. In 1990 Mindanao's population soared to about 14 M while that of the Philippines increased to 60.7 M in the same year.
2. Ecological invasion (e.g., indigenous populations are succeeded by the settlers).
3. The segregation of peoples on the basis of religious affiliation (e.g., division in 1980 of Lanao and Cotabato provinces and more recently, the ARMM).
4. Kaingeros (shifting agricultural cultivators) exerted tremendous pressures on the depletion of the forest cover.

5. The impact of the rapid population growth in Mindanao is summarized into: (a) exhaustion of the forest cover and depletion of other natural resources; (b) the effects on the indigenous peoples or tribes.
6. The displacement of the Lumad seems to be a trade-off for development (e.g., Del Monte in Bukidnon, Alson in Davao displaced the Matigsalog).
7. The Muslim displacement was found to be directly associated with the occurrence of violence during 1970-72. The question of land is a central issue in the Moro separatism.

### **Culture Defined in Relation to Development**

In a recent book, **Saving the Earth; The Philippine Experience** edited by Eric Gamalinda and Shelia Coronel (1993), the World Resource Institute study on the Philippines begins with a prediction that, in the next two decades, the country's environmental problems coupled with its rapid population growth will produce a subsistence crisis for close to half of its people – widespread hunger for millions of people moving from one place to another in search of food or a place to farm. The same study points out that policy makers are getting the message that economic growth cannot be pursued at all costs, that the environmental and natural resources are assets which must be considered for the future.

Fr. Rodrigo D. Perez III, O.S.B., defines culture as an essential factor of development, and not an obstacle. He further elaborated on the close relationship between culture in relation to development such as:

1. One function of culture is to enable man to cope with nature, that is, with the physical environment – with land, climate, and the abundance or scarcity of resources. Culture is man's effort not only to survive the challenge of nature but also to control it, "to subdue the earth and make it fruitful".
2. Culture enables man to enter into a stable, constructive, humanizing, and fulfilling relationship with his fellow human beings. The bond between one person and another and between a person and his community is realized through language and law.
3. Culture is both cause and effect of development as it enables man to advance and continuously transcend himself and endows him with a sense of fulfillment. Having tamed nature as far as he is able and having formed a community, man uses the resources of both nature and community not only to satisfy his needs but also to expand his horizons.

Culture as the totality of values, beliefs, forms of expressions, customs, institutions, and structures, is the motive, the means, the process, and the end of development. Development includes political, economic, and social development.

Magdalena (1995) pointed out that the key to environmental degradation is policy (Salita 1978), and political will to implement it. Furthermore, the ecosystem refers to the natural environment (more specifically, the forest cover and its indigenous inhabitants, flora and fauna), including the indigenous highland peoples.

Costello (1992) ends: "Even if we must conclude that Mindanao does not have a poor track record in keeping all of its promises which are made in its name, much of the blame for this must lie, not with the humble and hardworking people who now inhabit the region, but more with the Manila-based elites who have continued to construct a set of national policies which conform most closely to their own prejudices and interests".

### **PROPOSAL: MINDANAO CENTER FOR R & D**

Having defined the peoples of Mindanao, the relationship between culture and development, let me proceed by offering some suggestions. These suggestions are not new, in fact, one of the original suggestions was prepared in October 1983 entitled, **Consultative Research Council in Mindanao (CONRECOM)**. Let me elaborate on this further.

The major objectives are the following:

1. To afford social scientists and research institutions in the region an opportunity to summarize and exchange research findings over the past decade.
2. To assess the current state of social science research in Mindanao.
3. To discuss research needs and priorities for the years ahead.
4. To establish linkages and possibly a network throughout the island.
5. To prepare a regional report for the First National Science Congress in November 1983.

In another paper (Madale 1995), presented at MSU-General Santos during a joint conference with UP, the following seven (7) research topics of immediate concerns and directions on Mindanao:

1. A Deeper Understanding of Mindanao and the Mindanaoans.

The question of perspectives: those of the natives, the migrants, the intermarriages of both; those of the policy makers among the insiders and those among the outsiders. What are the dynamics of the interplay of perspectives of these actors in the formulation and implementation of policies? Is there conflict? complementation? compromise? Are there alternatives for policy decision making and what are they?

The ethnographic studies conducted much earlier during the colonial period have their own merits and biases. Further review is needed and should be pursued. Has scholarship on and in Mindanao progressed since then? Or, are we recycling those biases up to the present?

2. Policy Studies: Assessment, Evaluation, and New Directions

Related to the first concern is a general review and assessment of the controversy between and among the different theories of development such as core and periphery, top to bottom, polygon growth centers, corridors, and many others. Which is feasible and workable? Are there alternative models of development? What is really meant by People Empowerment? Do the people in the grassroots understand these jargons?

3. The Peace Process and the Autonomy Issue

Is there a workable and feasible formula of peace acceptable to: rebel groups, the GRP, the people? Is it possible to utilize alternative modes of conflict resolution/management like the use of traditional modes of conflict resolution/management? Will the Mindanao Consultative Peace Council work?

4. Peace Education/Peace Studies

Can Peace Education/Peace Studies be explored as part of the curricula at all levels? Can permanent structures that can maintain and sustain as well as support the teaching and promotion of the ideology of peace and nonviolence as a way of life be built?

5. Ethnicity, Religion, and Social Conflict

The encounter between the natives and the migrants has resulted in either conflict or mutual co-existence. What are the social dynamics involved in the encounter? Is it possible to document both the peaceful and the warlike encounters? Can the factors and actors that will explain the social and cultural dynamics of inter-cultural encounters be isolated and identified? Can a cultural mapping of conflict in Mindanao and its characteristics be conducted?

6. Autonomy and the Devolution of Power

Is political autonomy and the devolution of power the alternative to peace in Mindanao, or has it triggered other social problems? Is it possible to have three types of autonomy in Mindanao: ARMM, MNLF, and the Local Government Code? Or, is the confusion part of a scheme to perpetuate the conflict?

## 7. Human and Natural Resources of Mindanao

**Saving the Earth; The Philippine Experience** (Gamalinda and Coronel 1993) revealed the status of our natural resources. What concrete steps/projects have government and the NGOs done to preserve beyond the year 2000 what is left of our natural resources? What has been done about the continuous brain drain out of the country?

### MINDANAO CENTER FOR RESEARCH AND DEVELOPMENT

Integrating these ideas and proposals earlier mentioned, the creation of a Mindanao Center for R & D is long overdue. Let me elaborate on this further.

#### **Philosophy**

The philosophy of such a Center should be anchored on the basic principle of sharing and complementation. Furthermore, it should be anchored on the basic philosophy of the innate close relationship between man and his environment.

Like the proposal, CONRECOM as earlier mentioned, it is envisioned to serve as a channel for institutional linkages (both GOs and NGOs), to promote inter-ethnic and religious understanding. Through the Center, cooperative research projects can be undertaken by the different institutions in Mindanao and the approach should also be multi-disciplinary.

Duplication of researches can be minimized, if not avoided, and research funds as well as financial resources can be equitably distributed among academic institutions in the region. This joint venture and mutual cooperation and complementation among social scientists in Mindanao can be attained.

Likewise, through this cooperative venture social scientists in Mindanao can come together and exchange findings through news bulletins, conferences, and symposia or even through correspondence and the use of Internet and teleconference. A thorough assessment of the state of scholarship in and on Mindanao can be undertaken, and common areas of concern can be identified and pursued further in collaboration with other institutions and agencies. The end result of this academic collaboration and complementation is the enhancement of mutual understanding and intellectual enrichment among social scientists in Mindanao. The fact is that there is very little opportunity among social scientists in the region for social interaction. Somehow this inadequacy of opportunities breeds social enmity and competition, if not bias and prejudices against one another.

#### **Organizational Structure**

Institutions both GOs and NGOs as well as individuals/groups should be invited as members. What can be done for the moment is to list down the different research consortia in Mindanao and a federation of research institutions can be-

come the initial core group. There might be some problems though but we can not continue to remain in our own shells of inclusiveness and exclusiveness and look forward to a global village.

At the individual level there are different organizations in Mindanao across ethnic groupings, religious affiliations, business interests, political aggrupation, etc. – all of which can be harnessed to develop the potentials of Mindanao. Unless there is an attempt to cross “boundaries” which are both “real” and “imaginary”, the potential conflict will always be there. This is the “fear” that should be overcome by everyone in Mindanao and this is deeply rooted in one’s psyche.

The major areas of concern will be: (a) natural sciences and (b) social sciences. The natural sciences will include all issues related to the discipline in relation to Mindanao. The different issues were discussed by Gamalinda and Coronel (1993). Further studies can be undertaken.

On the social sciences, the study *A Filipino Agenda for the 21st Century* edited by F. Sionil Jose (1987) can be the start for further inquiries.

A more specific manuscript, also a result of a conference, is the book *Mindanao: Land of Unfulfilled Promise* (Turner et al. 1992), a very comprehensive manuscript that deals with the different issues affecting Mindanao.

### **Funding Requirement**

The Department of Science and Technology, Commission on Higher Education (CHED), State Universities and Colleges (SUCs), Office of the President in Mindanao, and other groups/institutions in Mindanao can provide the initial funding. For example, 5% of the research and development funds of SUCs can be utilized for the initial funding.

The Department of Interior and Local Government and other business groups in Mindanao can form the core to supplement the fund of the Center. Likewise, the National Commission for Culture and the Arts has funds which can be utilized to study the cultural communities in the region.

### **Institute of Indigenous Knowledge**

One specific Institute being proposed under the social sciences division is the Institute of Indigenous Knowledge. The global trend is to go back to the knowledge of indigenous peoples (IPs) and learn from them about mother nature. Modern medicine is moving towards herbal medicine. Development concepts have now considered indigenous principles, the close relationship between peoples and mother nature, between development and moral values.

From the IPs we learn a lot about spiritualism, morality, social relations, ecology, organic farming, and many others which are not documented, including traditional modes of conflict management and resolution. The concept of “spirit” and “soul” in everything that is created is an integral component of the environment and man. There exists an equilibrium between man, his environment, and all cre-

ation. Man's activities which tend to disturb this equilibrium bring about a lot of disaster for man.

Moral values are not only learned, taught, and practiced, they are handed down from generation to generation, the sources of which are embedded in the oral tradition of the peoples. Moral values which are anchored on "false" ideology do not last. They disappear fast like bubbles. When this happens, a vacuum is created and people become misguided because there is no specific direction to follow and no ideology to cling to. Western ideology does not work – it confuses the natives!

### **Functions and Concerns of the Center**

The following are suggested functions of the Center:

1. Identify and list institutions engaged in research, instruction, and extension services in the region.
2. Prepare a directory of social science and natural science scholars in the region.
3. Collate significant research materials both published and unpublished on Mindanao.
4. Establish a common place where research materials can be deposited as data base on Mindanao. Institutions with specializations can become centers for specific disciplines.
5. Publish and disseminate information (research results) periodically to every member institution here and abroad.
6. Establish linkages and networks with institutions engaged in similar research here and abroad.
7. Hold periodic meetings, consultations, and conferences to assess, evaluate, and make future plans on R & D for the region.

## **CONCLUDING REMARKS AND OBSERVATIONS**

### **Role of SUCs in the Promotion of S & T in Mindanao**

According to Fr. Perez III, a theory of development identifies the following aspects or stages:

1. Increased productivity and production.
2. More equitable distribution of the fruits of production.
3. Expansion of social services.
4. Reform of politics, economics, and social structures.

Each aspect or stage involves a process of initiation, planning, organization, and complementation, not to mention the adjustment of the pre-designed process to unexpected circumstances or to a moment of truth.



Development is for the masses. Development that fails to solve the problems of poverty, malnutrition, disease, unemployment, and illiteracy is not only a failure but also a betrayal. Let me also add that development without morality and virtue is equivalent to man without essence and purpose as a creation of God.

Professor Felipe de Leon, Jr. stresses the fact that we should rediscover the world from our own perspective, regain our strengths, and cultivate our oneness and solidarity as a people. Let us all participate in the noble objective of developing self-reliance, drawing from our collective spirit all the energy and courage we need to steer the country peacefully towards its creative destiny and sovereign majesty in the community of nations.

In another paper, Fr. Antonio S. Samson, S.J. made a study of schools in Mindanao and reported that Mindanao needs graduates in agriculture, technology and engineering, education, and business. His summary, recommendations, and conclusion include the following:

1. The data provided by the questionnaires show that tertiary level institutions are having a difficult time providing quality education. SUCs, except for a few are inadequately funded by government.
2. DECS regulations prescribe that faculty at the tertiary level institutions should possess appropriate graduate degrees. Data given confirm that the great majority of faculty in most schools do not possess appropriate graduate degrees.
3. The main expense in schools is faculty and staff salaries. Salaries of teachers have remained ridiculously low in comparison to business and industry.
4. EDCOM recommends that the financing of SUCs be reviewed, especially with regard to the present system of subsidizing all, and with regard to the efficiency of their use of funds.

In the same report, Dante B. Canlas observes that one area where the government can help is in advanced research. Support to research can be subsidized. Research generally produces benefits that redound to a great number of people. Government policy must be overhauled especially the tuition fee policy. Let me also add that unless we reexamine teaching loads of faculty members, research activities will always have the least priority. Sabbatical leaves should be encouraged to allow faculty to utilize the time for research undertaking. Incentives for research should also be reexamined and a more liberal and generous scheme should be adopted. In other words, we should build the culture of research.

### **Mindanao in the 90s**

Once again the picture of Mindanao is full of hope and promise. The latest ad is BIMP/EAGA and the so-called GEM Project. For the former, allow me to quote in full the ad about BIMP/EAGA from the Briefing Kit, December 1994.

“Mindanao is the second largest island in the Philippines covering about 102,074 sq. km. The total population in 1992 was estimated at 15 million, roughly 24% of the total Philippine population. The island has 23 provinces, 19 of which are in the mainland while 4 are island provinces. The largest province is Agusan del Sur, with an area of 8,965.5 sq. km.

“Surigao, Bukidnon, and Agusan provinces rising from the Northern Coastline have rich timberlands as well as deposits of nickel, copper, silver, and gold. Farther, west and south, in Davao and Cotabato, are the broad green fields of the Philippines’ largest banana, pineapple, and abaca plantations. Mindanao therefore remains the prime contributor to the nation’s agriculture production. Farther west, lies the Zamboanga Peninsula. The Sulu Sea yields pearls and corals as well as a hundred species of fish.

“Mindanao’s economy remains heavily oriented to agriculture, fishery, and natural products. Mindanao’s agricultural output alone accounts for 36% of the country’s total agricultural production. This focus on agriculture is due to favorable soil, climate, and abundant water resources. Just as important, Mindanao is outside of the typhoon belt. The island supplies 67% of the country’s corn, 23% of palay, and 62% of coconut. All of the country’s exports of bananas, natural rubber, and pineapples are produced in Mindanao. Mindanao’s industrial sector, however, contributes only about 14% of the nation’s total production.

“The Government’s Medium Term Public Investment Programme will focus heavily on infrastructure development in Mindanao. Specially, the plan is to complete the arterial road network on the island which is needed to fully develop trade among the regions in Mindanao. Improved infrastructure is expected to reduce post harvest costs, increase agricultural productivity, and create business opportunities for Mindanao’s entrepreneurs in the countryside. A recently constructed highway in South Cotabato has led to a 30% cut in transportation cost and a doubling in traffic.

“Northern Mindanao which is Mindanao’s gateway to Luzon and the Visayas, would likewise be a suitable site for investments in agro-processing and various agricultural ventures. In spite of recent setbacks, Mindanao will continue to have the country’s most inexpensive source of power due to its hydro resources. Electric power rates are 40% less than in Luzon and Visayas. The current power shortfall of approximately 200 megawatts which is more manageable than elsewhere in the country, is being addressed by several fast-track build-operate-transfer projects. In the long term, however, the government hopes that it can maintain Mindanao’s comparative advantage in energy cost by continuing to develop hydro and geothermal energy sources. Lake Lanao continues to have the potential to supply most of Mindanao’s power needs and an honest-to-goodness watershed protection and development programme is being put in place. PNOC is also proceeding with the development of the Mt. Apo plant which has the potential to produce up to 240 megawatts. Likewise, worth watching is the oil exploration programme of PNOC which is starting in the Cotabato River Basin bordering Cotabato City.

“At the same time, Davao City is being developed as the Regional Industrial Center. Davao has also recently become the center of mining activity. High grade gold and copper deposits have been discovered in the highly mineralized mountain range running down the eastern side of Mindanao. Lastly, Western Mining of Australia has had the most active exploration programme and is currently test drilling on two properties. Zamboanga City has also been identified as the leading trade center for Western Mindanao. The feasibility of establishing a free port or an export processing zone in Zamboanga is presently being evaluated. Zamboanga is geographically and culturally much closer to the northern part of Borneo and trade in these areas is readily expandable.

“Davao City is the country’s third leading city and the most developed area in Mindanao. It has the best airport, telecommunications, and pier facilities in Mindanao, and is the leading agribusiness center of the Philippines. Noted for its exotic fruits and flowers, Davao City has been identified as among the three major Philippine tourism destinations and a tourism development plan is underway” (BIMP/EAGA Briefing Kit, 1994).

In contrast, from another report, **Transforming the Philippines Into a Newly Industrializing Country (NIC)** (Denton 1993), observed that the Philippines did not receive a good return on its investments because of the following reasons/factors:

1. There are the distorted price structures for protectionism that caused investments to flow into projects with poor economic returns.
2. Corruption is another important factor in the inefficient use of investment. It is a covert activity and its magnitude is not readily documented.
3. The Philippines must revise its investment incentive structure so that more economically optimal investments will be made.

Concluding his recommendations, he stressed: “What is required for the Philippines to attain NIChood is for the nation – the people, the government, the private sector, the intellectual leadership – to accept the objective of exporting manufactured goods at a rate that will enable sufficiently high economic growth”.

Fundamental in this recommendation is the understanding what the day to day administration of policy, through rules and regulations, is what determines actual policy. It is necessary and perhaps sufficient, if manufactured exports are to grow, to have the bureaucracy internalize export growth as a primary national objectives. If this objective can be internalized, the day to day administration will evolve the mix of policies that will work (Denton 1993).

To conclude this discourse, the images that one sees of Mindanao evokes one’s imagination which converges on two conflicting perspectives: the illusions which bring about hope and aspirations including fear, and the social reality which brings out the one’s creativity and imagination. The former is seen to be perceived as the “migrant’s vision” while the latter is the “native’s worldview”. Do we accept these perspectives? Are they real or imaginary?

It is therefore suggested that a systematic research on the peoples, their culture and environment and their “worldviews” be undertaken with greater zeal and enthusiasm. There is a need to separate one’s illusions from social realities.

Secondly, the approach should not be compartmentalized rather, it should be integrated and the approach should be multi-disciplinary.

Thirdly, the principle of sharing and complementation (i.e., bayanihan spirit) should be further enhanced and developed. The *ato-ato lang* syndrome should be discouraged that breeds and encourages communities of ghettos with their own biases and prejudices.

If we are to build a global village in the near future, we cannot continue to live in our own little “shells” with our own “worldviews” fortified with centuries of hatred and a one-track mentality and outlook.

There is a need for a new philosophy that Mindanaoans should propagate, cultivate, and nourish – a humane society. Man as part and parcel of the whole creation of Almighty God must live in harmony with other creations or he will become an extinct species on Mother Earth.

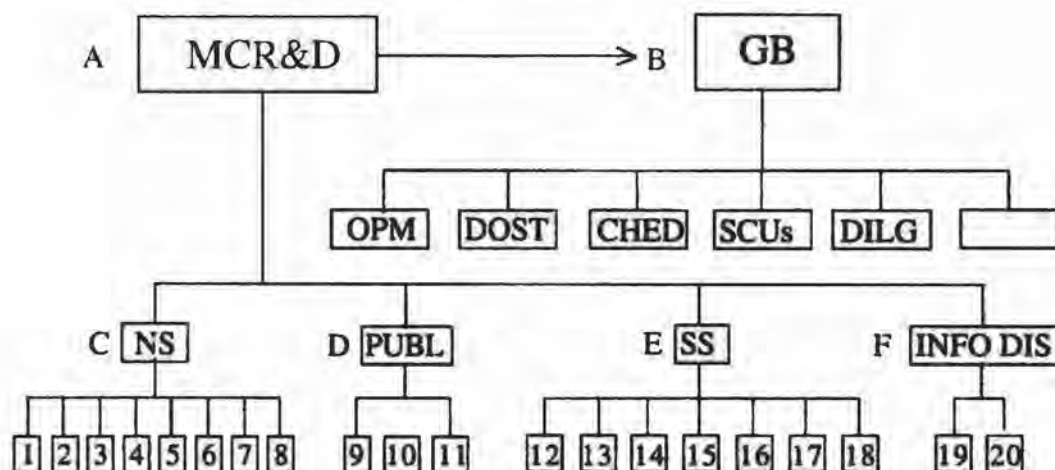
Once again, Prof. Felipe de Leon, Jr. stresses that: “there can be no national unity without a sense of pride (or *maratabat*) in being a Filipino. The basis of collective self-respect and respect for each other – and thus of national unity – is always a sense of one’s worth as a Filipino, a firm belief in one’s own strengths and creativity.”

Thank you and Godspeed!

#### LITERATURE CITED\*

\*The list of literature cited was not submitted by the author in time for publication.

**Appendix A: Mindanao Center for R & D**



**Legend:**

- A - Mindanao Center for Research and Development
- B - Governing Board: OPM, DOST, SCU's, DILG, etc.
- C - Natural Sciences
- D - Publications
- E - Social Sciences
- F - Information Dissemination
- 1 - Forestry
- 2 - Mining
- 3 - Mineral
- 4 - Air and Atmosphere
- 5 - Energy
- 6 - Waste
- 7 - Endangered Species
- 8 - Flora and Fauna
- 9 - News Bulletins
- 10 - Occasional Papers
- 11 - Journals
- 12 - Institute of Indigenous Knowledge
- 13 - Policy Studies
- 14 - Population and Migration
- 15 - Inter-Ethnic Relations
- 16 - Belief System
- 17 - History
- 18 - Peace Studies
- 19 - Conferences
- 20 - Dialogues

## Panelists

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### INTRODUCTION

I would like to confine my comments/reactions exclusively to the non-Muslim indigenous groups in Mindanao. Since Dr. Madale is a native Maranao I am disposed to yield to his descriptions, interpretations, and assessment of the Muslim people's role in the development of Mindanao. In his paper, Dr. Madale dealt comprehensively with a number of topics such as population/demography, the ethnolinguistic classification of the different indigenous groups of Mindanao, the role of culture in development, problems of the indigenous peoples (IPs) in regard to development, etc. Let me address some of the more productive and significant topics.

#### 1. Demography and Population Statistics

In addition to what Dr. Madale has already described and for a more visual appreciation of indigenous demography, I would like to show some pertinent statistics in regard to IPs.

- a. Fr. Pastel's ethnographic map of Mindanao on or about 1870
- b. The contemporary population distribution of IPs in 1980 and 1990 (National Census and Statistics Office figures) in selected provinces in Mindanao (Table 1)
- c. The following characteristics may be observed:
  - (1) Over a timespan of more than a hundred years the geographical distribution of the IPs of Mindanao has been remarkably consistent.
  - (2) At regional levels, the population of IPs has risen from 1980 to 1990. Among several groups the percentages of the total provincial populations have decreased. The Tiruray of Sultan Kudarat province have

been reduced from 55 households in 1980 to only 5 households for 1990.

- (3) The IPs have been minoritized in their historical places of origin and have been existing as enclaves in the midst of Visayan or Christian dominated communities. Many indigenous settlements are set apart from Christian communities in that while the latter are established in the barangay centers, the former are found mostly in remote upland sitios.

**Table 1. Population distribution of indigenous peoples (IPs) in Mindanao by region.**

Region	1980*			1990**		
	Total	IPs	%	Total	IPs	%
1. Region IX	438,878	152,155	34.6	3,150,906	1,160,591	36.8
2. Region X	410,722	21,043	5.1	3,502,674	160,855	4.5
3. Region XI	591,896	66,142	11.1	4,448,616	497,232	11.1
4. Region XII	393,263	187,112	47.5	3,167,540	1,435,871	45.3
Total	1,834,759	426,452	23.2	14,269,736	3,254,549	22.8

\*Based on a 20% sample, Census of Population and Housing, 1980. National Economic and Development Authority and National Census and Statistics Office, Regional Office, Davao City.

\*\*Based on a 10% samples, Census of Population and Housing, 1990. National Economic and Development Authority and National Census and Statistics Office, Regional Staff, Davao City.

## 2. Development of Mindanao: Boon or Bane to IPs?

- a. It depends on what definition or meaning of development is being used. If by development is meant rapid and unbridled industrialization or the implementation of fast-track projects then the IPs who are mostly uneducated and skilled will simply be left out and written off as part of the cost of development.
- b. On the other hand, if developers are guided by the idea of sustainable development or development for peoples (equitable development), there is a chance that the IPs can participate and derive some benefits from it. However, even with this understanding of development there are a number of problems.

- (1) The traditional economic system known to the IPs is the self-sufficient subsistence economy which was largely based on the cultivation of swidden or kaingin farms devoted to rice and root crops using field rotation and fallowing techniques.
- (2) Today, this system has changed to one of intensive cultivation, thanks to the influence of migrant farmers and government policies restricting IP communities to compact **although** unfamiliar settlements. This change has far-reaching implications on IPs as well as on their natural environment as anyone can see. Moreover, the impact of compact settlements on the uplands needs to be reckoned with the carrying capacity of the land. Judging from certain **persistent** accusations that kaingeros (which include IPs) are the major causes of the erosion of the uplands it would seem that computations have already indicated the danger signs.
- (3) This single technological change from upland to lowland cultivation technique actually requires the IPs to change their whole cultural equipment or lifestyle. At this point, I would like to ask, are we not asking a little too much of our cultural communities? Even if the trade-off were between the loss of their indigenous cultural and survival, the IPS who are mostly unschooled and unskilled have no assurance of getting what they traded for.

### 3. Cultural Diversity

Under these conditions, how are we to address the cultural diversity in Mindanao? I suggest that we borrow a perspective from the natural sciences which looked at biodiversity in a positive light. The cultural diversity of Mindanao would mean the variety of human **resources** which under any scheme of development is a positive, rather than a negative factor. We only need to know how to harness these different resources in order to make the IPs productive for the complex needs of our society.



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There is no doubt in my mind that outside of Divine will and foreordination, as some believe, the future of Mindanao envisioned in Mindanao 2000 lies in the extent to which science and technology are applied to every aspect of development and growth including even the purely cultural-religious aspect. In theory or practice, there is always some kind of scientific and/or technological approach needed in development. In fact, all researches and studies must be governed by the same scientific principle universally used. I like, therefore, if I can, to present my reaction to two papers I received for purposes of this NAST session on "Mindanao: Its People and Culture" in a manner directly related to science and technology as the central issue:

1. Reaction to the paper of Prof. Dr. Nagasura Madale of MSU-Marawi entitled "Mindanao: Its People and Culture and Their Contribution For a Dynamic Mindanao".

I have gone, as thoroughly as I could, through the rather long essay by a good friend, Dr. Madale, and found it both interesting and, in a sense, disappointing. Interesting-because it demonstrates an impressive grasp of what I call the "general impressions of and trends in Mindanao" as portrayed in publications on Mindanao, past and present, reliable and unreliable. After going through two-thirds of the essay, there is hardly anything one can pick out as a basis for serious critique. What we have is an evaluation of what have been done in general terms. It is a resumé and, in many instances, a repetition of what have been said in years of conferences and seminars on Mindanao issues and problems. In brief, there is nothing really new when we look objectively at the enumeration of generalities on Mindanao researches, development plans, structural changes, problems and issues, etc. The only thing new, if any, is the proposed creation of two structural mechanisms for Mindanao's dynamic growth.

1. A Consultative Commission for sharing and complementation. While I share the view that, indeed, there is a need for sharing and complementation of data, resources, efforts, etc. by both public and private sectors, I do not share the urgency of creating another super body over Mindanao to perform a function that should be done or is being done by agencies or institutions in and for Mindanao, both public and private. Examples: NEDA, MSU System, OPM, SPCDP. In short, is not the proposed structure redundant?
2. An Institute of Indigenous Knowledge. Again I absolutely share the author's focus on the indigenous roots of Mindanao culture as imperative. But the creation of a separate, super institute is to overlook existing programs, academic or otherwise, that have already been integrated into the curricular or research programs of institutions. What I see as a pos-

sible project is how the various studies on indigenous traditions can be systematically published and disseminated through direct institutional changes without creating a structural intermediary that might demand another level in an already bloated Mindanao bureaucracy.

But more important than the foregoing comment is what has not been stressed in Dr. Madale's essay – the more specific areas of local/regional concerns that require the use of concrete, scientific, and technological reinforcement. For purposes of illustration, let me just use the case of Tawi-Tawi's "small industries" to underline my point. I have identified, at least, five indigenous small industries of Tawi-Tawi and Sulu that have been persistently preserved simply because they represent local sources of livelihood for the "small people", as well as materials for cultural rituals. These are:

- a. "tutup-baluy making", which is dependent on the pandan leaves for raw materials. Ecological planning is needed to preserve, protect, and improve island areas where pandan is found or can be grown abundantly.
- b. "boat-building" of Sibutu, Balimbing, and Tabawan, which is dependent on forest logs and other trees and plants for materials. Illegal logging and lack of a scientific way of forest preservation explains local indifference to ecological problems.
- c. "weapon-making" of Patikul, which has preserved the ancient character of art and craft of Tausug tradition. Examples: *kalis*, *barung*, *saruk*.
- d. "various culinary delicacies," which are an integral part of rituals and festivities in Sulu and Tawi-Tawi. Examples: *baulo*, *ja*, *panyam*, *daral*, *lengkong*, etc.
- e. "weaving" of heirloom type of textile products such as the *habul*, *pis*, *batawi*, etc.

In brief, the foregoing small industries not only in Tawi-Tawi and Sulu, but also throughout Mindanao, deserve to be given scientific and technological assistance because they usually affect the lives of the less privileged in local society. Consequently, enhancing the productive and creative capacities of these small industries for economic and cultural purposes ultimately improves the quality of life of the small people and therefore, socially contributes to the expectations of Mindanao 2000. Thus, the prospects for science and technology to assume a much greater role in Mindanao's development and progress rests on the extent to which individuals and institutions in Mindanao, mandated or expected to carry out plans and projects, can really go down clearly and realistically to the lowest unit of society and carry out the goals envisioned. Issuing of orders, circulars, instructions, etc., while certainly necessary and required in a bureaucratic system, has been perceived as more of a system of passing responsibility (not necessarily authority) from one level and, ultimately, resting on the shoulder of the "small people" in the bureaucracy. There must be a way of changing this perception by real performance individually or collectively.

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In his paper, Dr. Madale mentions that population data from Mindanao and Sulu are not up to date or uniformly accurate. This observation is very important in the context of development, because population and other demographic data are very essential in formulating policies and programs in development.

Census-taking in Mindanao, particularly in the countryside of Muslim-dominated areas is oftentimes inaccurate because it is difficult to conduct due to several factors: (1) the hesitance of the people to be part of anything that is "put on record" by government functionaries; (2) often, when the census-taker visits the household, only minor members of the family are present, and there are no follow-up visits by the census-taker; and (3) some census-takers are known to make their own estimates or even "manufacture" figures in their census forms.

Perhaps an intensive information program should be conducted, preferably in the vernacular, before any census-taking activity, to stress the importance and rationale of the census.

Item 3 (p. 11), under the section "Mindanao's Peoples and Population" of Dr. Madale's paper, he states: "In Zamboanga, they are the Chabacanos who were brought to the Philippines from Ternate in the Moluccas in 1663, then in Zamboanga in 1718."

My understanding is that the word "Chabacano" pertains to the dialect of the Zamboangueños. It was the dialect, or language, a kind of bastardized or pidgin Spanish, that was brought by the people of Ternate in Malacca, to Cavite (where they gave the same name, Ternate, to the specific place of their settlement), and in turn, when some of these Ternatans were brought by the Spaniards upon their return to Zamboanga in 1719, they also brought this dialect with them, which was adopted by the natives of Zamboanga.

Information and education are very important components of any program of development for Mindanao, and in conceptualizing such information and education programs, it is very important that these be designed with a background knowledge on the culture and history of the people of Mindanao. Marketing specialists have already acknowledged this, albeit in a superficial sense. For example, video commercials like the one depicting a Muslim girl using telecommunications; a baby powder and disposable diaper ad showing a Muslim mother and child, and even a Muslim lady among other matrons looking over a certain refrigerator brand.

The population control program, especially, will benefit from this kind of conceptualization. Such a program that is structured according to their ethnic value systems and religious beliefs would be more effective.

A study of the belief and value systems of the people of Mindanao will be of immeasurable help in making such programs acceptable and comprehensible. In the case of technology transfer, for example, workers in this field can orient people according to the tenets of their belief and value systems.

I fully agree with Dr. Madale that there should be a common place where research materials can be deposited as data base on Mindanao, and made available to government agencies involved with development, so as to make their programs and policies more realistic and acceptable. In the regional conference on history conducted by the National Centennial Commission last May, such a proposal also came up, and the participants decided to set up this repository of research data and other materials and documents on Mindanao in the University of the Philippines Mindanao in Davao City.

On proposed research topics, Dr. Madale cites research on ethnicity, religion, and social conflict. This is especially true in multi-ethnic communities like that in Zamboanga City, where an underlying and simmering inter-ethnic conflict is seen as a great deterrent to peace, and by extension, to development and progress.

A more manifest illustration of this, to borrow a term from Dr. Madale, is the "*ato-ato lang*" mindset, or "*kita-kita lang*". The Christian populace has a tendency to view government programs as applicable to them only, probably because by virtue of their education and awareness they are the only ones who can comprehend the intricacies and applicability of such programs; while conversely, the Muslims regard themselves as "outside" of whatever emanates from the government, simply because by its very nature (government issued), it is, ipso facto, "Christian-oriented" and therefore there is a tentative, hesitant attitude towards such programs at best, a totally negative one at worst.

Why does religious identity supersede ethnicity in the people's perception of things? Is there awareness of their ethnic identity, where they can find common grounds on which to construct a unity of sentiments and aspirations? These are examples of problems that such research should seek to answer.

Finally, should there be a Mindanao data bank, we should consider these questions: how can we translate such data which expectedly would be expressed in scientific and technological language, into terms that can benefit the village dweller? How can such a database be used as the foundation for policies and programs that can be directly applicable to the countryside so as to improve their productivity, raise the level of their social awareness, and encourage their involvement in a collective aspiration for a better life?

In short, we should, at all times, consider the importance of the vernacular, and the "micro-level" realism of the barangay, of the village, in the effort to re-orient the populace and make them more receptive and more involved in the over-all vision of progress and social uplift.



## **PLENARY SESSION II “MANPOWER DEVELOPMENT FOR MINDANAO’S INDUSTRIES”**

### **Manpower Development for Mindanao Industries**

**IRENE M. ISAAC, Ph.D.**

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### **INTRODUCTION**

#### **The Mindanao Upswing**

For the first time, the Annual Scientific Meeting, its 18th in a series, is being held outside Metro Manila. All roads for all scientists and those aspiring and interested lead to Davao. It is a double treat – an annual scientific sharing session and a glimpse of the fulfillment in the land of promise.

My generation went through textbooks calling Mindanao the land of promise and painting pictures of hinterlands and bumper harvests of camote and other crops. This generation sees the land of promise in terms of PAL Terminal 2, shopping malls, highrises, and urban heavy traffic in Cagayan de Oro and Davao City. The modern Mindanao sees the land of promise in Professor Pat Sto. Tomas teaching in UP Mindanao, Tito Inocencio farming asparagus in GenSan. There are so many of them who have shown faith in the fulfillment of the promise. Those who professed belief early are now reaping the rewards.

There is no stopping Mindanao. It is no longer the backdoor. It is another frontdoor.

#### **The Demand on Manpower Development as a Tool for Growth**

The old picture of the land of promise as abounding in natural resources is no longer true. The lessons of the Asian tigers, our developed neighbors, is that the competitive advantage is in human resources. The importance of a well-educated,

skilled, disciplined, and motivated workforce is consistently underscored amidst a background of continuing rapid technological change, globalization, and an increasingly competitive world market. An educated and skilled labor force is able to adapt faster to the ever-improving technologies and thereby increase productivity level and worldwide competitiveness.

### **Market-Oriented HRD Strategy**

The strategy for human resources development in Mindanao is one that will support the economic growth in terms of critical labor supply but specially in terms of creating added employment opportunities that will improve the quality of life of the people in the ratrace world of international competitiveness. HRD efforts in Mindanao should continually contribute to the attainment of fundamental values of poverty alleviation and equal access to education and empowerment so that all citizens may participate in the process of economic growth and development of Mindanao.

## **IMPLICATIONS OF KEY ECONOMIC TRENDS ON HRD**

The recent major economic trends pose major imperatives for the development of human resources worldwide and their impact is heavier in developing areas like Mindanao.

### **Economic Restructuring**

The decision of our government to restructure our national economy towards global market competitiveness is premised on the objectives of creating additional jobs for the increasing number of Filipino workers in the long-run. However, in the short-term, some displacements may occur as structural adjustments take place in some industrial sectors that are affected by the shift to shift competition in the export market. Safety nets are installed in terms of skills upgrading, transfer training, or entrepreneurial assistance to give security for workers that may be affected. As the President said, skills training is not only an investment, it is a form of empowerment.

### **Changing Patterns of Trade and Competition**

As the economy becomes more competitive, the industrial environment becomes more volatile where quick response and flexibility are most crucial factors, where workers must not only be adaptive to new job opportunities but also to the ability to learn new competencies with ease and efficiency. The role of the employers becomes crucial to HRD because they are in the best position to clarify the HRD implications of their forthcoming business decisions, what new competencies will be required, and what mode of skills acquisition may be forthcoming.

It is anachronistic that competition comes now in a borderless economy. In the borderless economy of the BIMP-EAGA for example, there will be a freer flow of both human and capital resources. The attraction of higher wages in labor-short economies will certainly lure many of our educated and skilled workers to the worksites in the neighborhood. As it is, Brunei and Malaysia are experiencing

shortages of specific types of manpower, and up to some extent, they have become dependent, in varying degrees, on expatriate workers. Indonesia's deregulation of the banking industry in 1988 increased the number of banks drastically and created a critical shortage of bank managers and executives. Right now, some 600 Filipino managers are estimated to be occupying senior management positions in Indonesian banks and large corporations. Many analysts believe it will take another 5 to 10 years before Indonesians can fill these positions currently held by expatriates. On the other hand, the cases of Filipino skilled workers in the jobsites of Malaysia and Brunei are fairly well-known. As economic integration accelerates, these manpower problems will become more acute and could already be felt in some sectors and some areas in Mindanao. It is a good strategy to start the competition to retain our best workers within our country.

### **Technological Changes**

I do not have to belabor the point of intense technological change that we are experiencing. Suffice it to say that as we visit the farms, the factories, and the service areas that are here or are being set up here in Mindanao, we are dazzled by the demand on HRD and the need to focus on the most critical and essential needs. It is imperative to thoroughly analyze the emerging technological changes in priority industries.

The more flexible our workforce, the better we are able to acquire and use appropriate technology required to produce better quality goods and services at lower cost and to shift production processes to wider and more competitive world markets. These changes are expected to demand higher skills and competencies which will alter the occupational qualifications of the Mindanao workforce. There will be industries that will require fewer manual skills and more innovative thinking, improved planning and designing skills, and greater capacity for teamwork and integration. Skills profiles of workers will combine cognitive, analytical, and abstract thinking with manual and adaptive skills.

### **CURRENT POLICIES AFFECTING HRD**

Our national policies affect demographic and economic developments and to a large extent influence job opportunities for workers with different skills. Our economic and social policies at the same time afford the incentives for workers to acquire skills and for employers to provide human resource development opportunities.

Wage and employment policies are supposed to guide workers in the maximum utilization of their competencies and employers in using their resources to invest in the upgrading of the capability and productivity of their workers. Unfortunately, market signals, the way they are, do not reflect the true social value of capital for HRD. Such distortions generally arise because of government interventions instituted at pursuing, also, economic and social goals. In this scenario therefore, the so-called mismatch of manpower supply and demand becomes a structural problem, an imbalance in the marketplace. It is a phenomenon created by the HRD system and



as such can be corrected within the same system. Solutions to this structural mismatch essentially lie in moving HRD policies in tandem with efforts to shape the general economic and social policies that improve labor market signals and manpower development incentives thereby strengthening the role of market forces in resource allocation for HRD. There is a need to seriously consider a mechanism that will even the playing field and help compensate and offset distortions in the labor market. The traditional resource allocation scheme for HRD, given the present rate of development in Mindanao, will not be supportive of a relevant and responsive HRD strategy so much so that the market-oriented, private sector-led approach will have to be advocated and put in place if we are to achieve our HRD goals.

### **THE BIMP-EAGA PROJECTS AND DIRECTORS FOR HRD**

Pursuant to the initiatives of the heads of governments of Brunei Darussalam, Indonesia, Malaysia, and the Philippines, the designated ministers of the four countries met in Davao City on March 24 to 26, 1994 to formally agree on the establishment of the BIMP-EAGA, the Brunei-Indonesia-Malaysia-the Philippines East Asia Growth Area. This area is composed of the whole of Brunei Darussalam; the provinces of North Sulawesi, East Kalimantan, and West Kalimantan of Indonesia; the states of Sabah and Sarawak and the federal state of Labuan in Malaysia; and Mindanao and Palawan in the Philippines. Cooperation in the EAGA covers the fields of air linkages, sea transport and shipping services, fisheries cooperation, tourism development, environmental protection, HRD, agro-industry, capital formation and financial services, and forestry. The EAGA was designated to be private sector-driven while the governments are expected to play a facilitating role in exploring ways and means to strengthen the environment for cooperation by gradually dismantling barriers.

#### **The ADB Recommendations**

The Asian Development Bank provided technical assistance for a study that would identify areas for public and private sector economic cooperation which will be mutually beneficial to the component areas of the EAGA; identify specific pioneer projects and programs which will enhance synergistic growth in the regional economy; analyze the over-all economic conditions in the component areas and identify comparative advantages and complementarities; review existing cross-border activities and identify major socio-economic constraints to closer regional cooperation; determine and prioritize the public sector policies, programs and projects which are required for the development of the BIMP-EAGA; and define governmental involvement in the implementation of the initiatives.

Quoting from the executive summary of the report of the study team commissioned by the ADB, "The broad strategic framework proposed for human resources development in EAGA, based on the sectoral analysis and taking into account the need for high-demand skills necessary for implementing the EAGA's Strategic

Development Plan, incorporates several key elements, viz., regularizing and improving the acceptability of people mobility, focusing attention on the important needs for improving basic education, proposing the establishment of high-demand skill training centers, promoting skills training for rural women, promoting health and safety at work, exploiting and developing complementarities in higher education, cross-cutting concerns with conservation and environmental management, and encouraging research and development. Within this broad framework, the two key elements relate to people mobility and skills training.

The study team recommended twenty-eight projects: 6 for people mobility, 12 skills training centers, one skills development center for rural women, and 9 miscellaneous projects dealing with supply of rural teachers, industrial health, higher education, research and development, and the nature of rural poverty. Tables 1, 2, and 3 show the project titles, constraints, and benefits of the recommended HRD projects.

**Table 1. Summary of constraints and benefits of people mobility projects**

<i>Main existing constraints</i>	<i>Project No.</i>	<i>Recommended initiative</i>		<i>Expected impact/benefits</i>
		<i>Action type</i>	<i>Project title</i>	
No official Filipino representation	HRD 1	Policy/project	Establishment of a Filipino Consulate Office in Kota Kinabalu and Sub-Office in Sandakan	Confidence building; representational support for documentation
Existence of large members of undocumented workers	HRD 2	Policy/project	Regularization of undocumented workers in Sabah and the Federal Territory of Labuan	Boost for regional cooperation; regularization of the workers undocumented workers
Lack of data on foreign workers and their impact	HRD 3	Project	Three-part study of foreign workers and their impact	Important policy-relevant data about foreign workers
Difficulties and high cost of obtaining documentation	HRD 4	Policy/project	Decentralization of foreign workers and their impact	Easier and less costly for migrants to obtain documentation
Major source location of undocumented workers	HRD 5	Policy/project	Establishment of a one-stop Consular Officer/Labor Bureau in Sulu/Tawi Tawi	Awareness of importance and ready availability of documentation
Lack of data about pros and cons of using simplified documentation	HRD 6	Project	Study on the introduction of SMART cards/restricted passports for use within EAGA	Policy-relevant assessment about use of simplified documentation

**Table 2. Summary of constraints and benefits of skill-training projects**

<i>Main existing constraints</i>	<i>Project No.</i>	<i>Recommended initiative</i>		<i>Expected impact/benefits</i>
		<i>Action type</i>	<i>Project title</i>	
Lack of skilled wood craftsmen	HRD 9	Project	EAGA Center for Downstream Wood and Furniture Making Activities	Improved supply and quality; higher value added employment
Lack of skilled tourism manpower	HRD 10	Project	EAGA Center for Tourism, Hotel and Restaurant Management Training	Improved supply and quality; higher value added employment
Lack of skilled maritime manpower	HRD 11	Project	EAGA Center for Maritime Activities	Improved supply and quality; higher value added employment
Lack of skilled off-shore engineers	HRD 12	Project	EAGA Center for Petroleum and Gas	Improved supply and quality; higher value added employment
Lack of skilled modern sector farmers	HRD 13	Project	EAGA Center for Farming and Agri-Industries	Improved supply and quality; higher value added employment
Lack of skilled tele-communication and IT manpower	HRD 14	Project	EAGA center for Telecommunication and Information Technology	Improved supply and quality; higher value added employment
Lack of financial services manpower	HRD 15	Project	EAGA Center for Financial Services	Improved supply and quality; higher value added employment
Lack of middle-level construction workers	HRD 16	Project	EAGA Center for Building Construction	Improved supply and quality; higher value added employment
Lack of shipbuilding maintenance workers	HRD 17	Project	EAGA Center for Shipbuilding Maintenance and Repairs	Improved supply and quality; higher value added employment
Lack of expertise in starting-up, running, and maintaining businesses	HRD 18	Project	EAGA Center for the Development of SMEs	Improved entrepreneurial skills; more efficient private sector
Very low skill level of rural women	HRD 19	Project	Skills development program for rural women	Improved skill level of rural women; employment creation
Lack of skilled middle-level technical manpower	HRD 20	Project	EAGA Center for Technical and Manufacturing Training	Improved supply and quality; higher value added employment
Lack of skilled marine science and marine resource manpower	HRD 21	Project	EAGA Center for Marine Science and Marine Resource Management	Improved supply and quality; higher value added employment

**Table 3. Summary of constraints and benefits of miscellaneous HRD projects**

<i>Main existing constraints</i>	<i>Project No.</i>	<i>Recommended initiative</i>		<i>Expected impact/benefits</i>
		<i>Action type</i>	<i>Project title</i>	
Poor attainment levels; lack of rural teachers	HRD 7	Policy	Incentive scheme to encourage teachers to work in deprived rural areas	Improved attainment; more teachers willing to work in rural areas
Lack of data about how to increase supply of rural teachers	HRD 8	Project	Study of ways of increasing supply and quality of teachers in rural areas	Policy-relevant data about how to increase supply of rural teachers
Poor industrial health and occupational safety	HRD 22	Project	EAGA Center for the Promotion of Industrial Safety and Occupational Health	Increase awareness about, and improvements in, industrial health and occupational safety
Lack of regional coordination	HRD 23	Project	Federation of EAGA Universities	Exchange programs and economies of scale
Lack of research on EAGA	HRD 24	Project	EAGA Studies Center	Support for business community
Lack of awareness and enforcement of conservation and environmental control	HRD 25	Project	EAGA Institute for Forestry Conservation and Environmental Management	Improved awareness and enforcement of conservation and environmental control
Lack of research and development activities	HRD 26	Project	Research and development of geothermal and mineral potential	Research and development in support of public and private sectors
Lack of recognition and acceptance of degrees and diplomas which impairs the exploitation of comparative advantages	HRD 27	Project	Study on the Sharing of Expertise and Resources in the Medical and Nursing Fields, including Herbal Medicines	Plan for overcoming constraints and exploiting complementarities
Widespread rural poverty throughout EAGA	HRD 28	Project	Study on the nature and dimensions of rural poverty	Improved understanding and action plan to reduce rural poverty

### **Banner Projects and Early Action Plan**

The HRD Working Group started meeting in November of 1994 and has since established a BIMP-EAGA Labor Market Information, adopted model occupational skills standards and benchmarked national skills standards against that model as stepping stones to mutual recognition of skills standards and ultimately technical education credits, and an umbrella framework for the exchange of experts, teachers, and students. In its 4th working group meeting in East Kalimantan, Indonesia, it recommended to the other sectoral working groups that they take up sector-specific HRD programs. The people mobility working group would work on the people mobility proposals and adopt within the HRD Working Group those projects that are generic in nature. It did adopt as its banner projects in the next two years the implementation of the exchange program, a study on skills shortages in the subregion, the EAGA Program for the Development of SMEs, the EAGA Network of Centers for Technical and Manufacturing Training, and the Sharing of Expertise and Resources in the Medical and Nursing Fields.

### **COMPONENTS OF THE MINDANAO HRD STRATEGY**

With such bright promise for the land of promise, the human resources development program in Mindanao therefore will have to live up to its renown as the best workforce in the subregion and the most obvious advantage of Southern Philippines over those of the other components areas. But a lot of the necessary components will have to be in place.

#### **Quality Basic Education**

Any well-meaning HRD program would require quality basic education that would bring about a quality of life in its social, spiritual, and material dimensions. The quality of life of people in Mindanao will increasingly depend on their employability and productivity which in turn will be determined by their mobility and flexibility to learn and adopt new skills. Quality basic education provides an absolutely essential base for further development of education and skills as it is the platform for trainability and for new and higher level of skills.

Basic education includes elementary, secondary, and alternative or supplementary nonformal education aimed at providing the knowledge, skills, and attitudes that allow the broad foundation for lifelong learning. In strengthening quality basic education, particular attention must be given to improving science, mathematics, and communication competencies as well as increasing awareness and understanding of the culture and attitudes of different people. This need for understanding of culture is specially pronounced in the setting of diverse cultures in Mindanao. Equitable access to these improvements should be emphasized to provide the rural youth with opportunities for higher levels of learning.

### **Responsive Technical-Vocational Education and Training**

Technical-Vocational Education and Training. The government has initiated recent reforms in the area of technical-vocational education and training or TVET. These reforms are aimed at preparing Filipino workers for the impending greater international competition. These reforms are the Dual Training System Law and the Technical Education and Skills Development Authority Act, which formed part of the recommendations set forth by the Joint Congressional Commission on Education.

The Dual Training System Law applies to all public and private educational institutions, training centers, agricultural, industrial, and business establishments duly accredited to participate in the dual training program, aimed at strengthening tech-voc education and training in the country in order to be assured of a growing supply of educated and skilled manpower. These establishments and institutions, therefore, share the responsibility of providing would-be workers with the best possible job qualifications. It is also designed to promote greater private sector participation in TVET.

The importance placed on TVET is clearly manifested by the enactment of RA No. 7796 which merged the National Manpower and Youth Council and the Bureau of Technical Vocational Education of the DECS, and the apprenticeship program of the Bureau of Local Employment (BLE) of the DOLE into one institution called the Technical Education and Skills Development Authority or TESDA. This body shall ensure equal and strong participation of industry groups, trade associations, and employers and workers in the development and implementation of skills development programs. Moreover, the TESDA has been mandated to establish a national fund for TVET to finance efforts that will build the TVET capability of private employers and local government units.

The full implementation of the dual training system and the TESDA in Mindanao therefore will help operationalize its HRD strategy.

### **Rational College-Level Education**

The educated unemployment problems are still real. The job opportunities are not increasing as fast as institutions are producing college graduates. Moreover, there is an apparent oversupply of graduates in arts, administrative, and humanities courses. The solutions here do not lie only in the supply side, that is, the change from less arts to more science courses, but also in the demand side, like reviewing salary structures and hiring and recruiting practices of firms. It will also help if colleges and universities focus on specific technologies needed by industries in their respective areas.

### **Efficiency in the Labor Market**

Understanding and anticipating the trends and needs in HRD are vital for all aspects of Mindanao's economic growth. These require analysis of labor markets to allow sound forecasting of trends and needs in HRD and development of appropriate measures. A comprehensive analysis would require looking ahead at emerging opportunities as well as impediments in the efficient functioning of the labor markets in both the medium- and long-term so that the populace and HRD institutions can be guided in their decision-making.

To put this in operational terms, existing structures on labor market information like the DOLE Public Employment Service Office (PESO) should be strengthened to form a Mindanao Labor Market Information System which can later be linked to similar LMI systems within the EAGA region.

Since economic integration and keener competition are also expected to bring in their wake adjustments and transformations in workplaces as well as in work arrangements, a well functioning industrial relations system has to be put in place.

### **Sectoral Approach to Skills Needs Assessment**

Manpower planners have always been maligned for not being able to forecast the skills demand so that training and education for supply can be matched and an imbalance can be avoided. But the more important issue here is not whether manpower demand can really be forecast sufficiently but whether planning should be based solely on the basis of forecast skills shortages. Some manpower planners have advanced the theory of market forces or left it to the private sector who know best what they need, when, and how much. This theory has been criticized as a government abdication of responsibility in a developing country where huge training resources required will be out of reach of the small and medium enterprises.

TESDA has shifted from the national manpower planning approach to labor market analysis. Accordingly, the PSALM approach: a Manpower Development Strategy that is Policy-oriented, Sector-focused, and Labor Market-driven, has been adopted. This allows manpower planners to be more focused on specific areas, using more limited data. In the more focused sectoral approach, planners and HRD specialists, whether in local government or industry, are able to examine the structural balance in the stock and flow of key skills in a particular sector, determine the causes of key skills shortages, get the ultimate users (employers) involved in the analysis and conclusions, and get industry to identify training priorities. Figure 1 shows a framework for the sectoral approach.

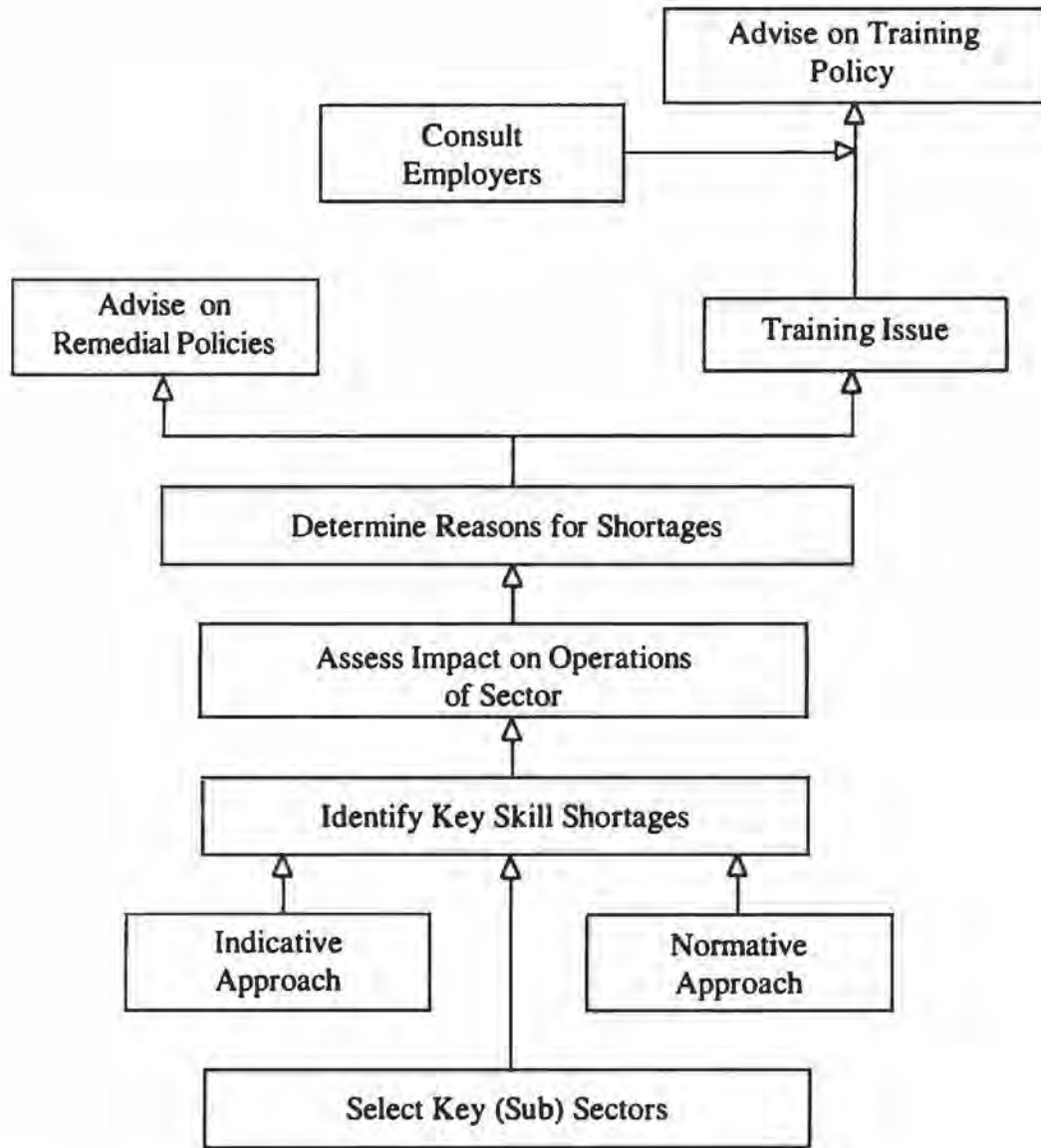


Figure 1. Sectoral approach to the assessment of skills needs and the identification of training priorities.



### **Supportive Business Environment**

Mindanao businesses have always been eclectic, choosing the best option there is from diverse sources, systems, or styles. This is what made them strong. This is perhaps because they have been far from “imperial” Manila. As a consequence, they will be responsive only to an HRD system which will be good for them, in the short run, and I believe that now they look further out and are willing to invest for the future. HRD will be an area that Mindanao will support because it will have to compete for the best people in the open field of the EAGA.

### **Consultation and Consensus**

The diversity in Mindanao has made its people strong. And this is what has always brought both the local and national leaders to seek consensus. Consultation, if not consensus, has been ingrained in the way of life in Mindanao. HRD will not thrive otherwise.

To recapitulate, economic restructuring, the changing patterns of trade and competition, and the fast technological developments have a strong impact on manpower development. At the same time economic and social policies affect the general make-up of the HRD framework and programs specially in resource allocation. The growth of Mindanao and its immediate environs necessitates an internal action that will cater to the local requirements in the global context. The Mindanao HRD Strategy therefore, for it to be responsive, should have all the components of quality basic education, responsive tech-voc education and training, rational collegiate education, efficient labor markets, sectoral assessment of skills needs, and a supporting business environment, all based on consultation and consensus.

I will continue by addressing specific questions and issues that you have.

## **Panelists**

### **LUIS P. LORENZO, JR.**

*President and Chief Executive Officer, Lapanday Holdings Corporation  
Makati City*

### **COMPANY PROFILE**

#### **Employs 16,000 People in Mindanao**

- \* 13,000 – Agriculture
- \* 3,000 – Food processing/manufacturing/sales and distribution

#### **Employee Work Force – From Farm Laborer to Ph.D.**

#### **Products – Food-Consumer Products**

- \* Fruits
- \* Vegetables
- \* Juices
- \* Carbonated drinks
- \* Processed food

#### **Family Has Been Involved in Mindanao Development Since 1920's**

- \* Now into 3rd generation

#### **HRD Philosophy**

- \* Strong in people development
- \* Strong in cooperative movement
- \* Belief in improving quality of life of people (employees and communities we exist in)

### **SOLUTIONS**

#### **Davao Trade School - Engineering Skills**

- \* Civil
- \* Mechanical
- \* Electrical
- \* Computer skills

**Corporate Initiative on Training**

- \* Formal
- \* On the job

**Augment Income on Farms**

- \* Livelihood programs
- \* Credit cooperative
- \* Herbal medication programs

**Scholarships and Internship**

- \* Programs from some local schools

**Transfer Technology**

- \* Benchmark vs international competition

**Agri-Industrial Park**

- \* On land where there is creeping urbanization

**Strong Labor-Management/Stockholder Communication Relationship**

**Continue Lobbying in Manila**

- \* Communicate with government as to what is best for the people in our areas

**CHALLENGES – OPPORTUNITIES**

**Rising Compensation and Benefits Expectations in Labor**

**Intensive Export Industries**

- \* How to keep people gainfully employed and still be competitive internationally

**National Government**

- \* Wants progress and development and yet has difficulty understanding our situation

**Markets for Finished Products from Mindanao are Limited**

**Except for Top Students**

- \* Quality of Mindanao students below par for English and technology

**Large Unemployed and Underemployed Force**

**Creeping Urbanization**

- \* High cost of land

**MANUEL M. ORIG**

*Vice-President, Davao City Chamber of Commerce and Industry, Inc.*

First of all, let me congratulate Dr. Irene M. Isaac for her incisive paper on the subject Manpower Development for Mindanao Industries. It is not very often that you find a scholarly paper written about the subject especially one involving Mindanao. Dr. Isaac's paper will certainly be instructive to HRD practitioners of Mindanao.

There are a number HRD Projects presented in Tables 1 to 3 of Dr. Isaac's paper. The tables indeed indicate that we are well aware of our constraints and, in fact, know the corresponding programs to address our needs, but have we really assessed whether the projects have proven to be efficient and successful? Are these projects leading us towards the direction that we are heading?

**ON STRENGTHENING OF BASIC EDUCATION**

While the DOST has a program for strengthening science teaching through the Regional Science Teaching Centers (RSTCs), the funds remain to be accutely limited. Alternative strategies have to be adopted such as clustering and cascading, to extend the reach of the training programs conducted. In many cases, training programs are not implemented at the classroom level because of lack of logistics and administrative support. Other concerns include overloaded elementary and secondary school teachers and science teachers not holding science degrees.

**ON DISPERSAL OF TECHNOLOGICAL AND SCIENTIFIC EXPERTISE**

We in Mindanao experience acute shortage of experts to steer Mindanao industries. We recognize that a great number of experts are still concentrated in Manila. What Mindanao needs therefore is a program for extended stay of experts in Mindanao for at least one year, to be based at institutions such as the DOST, UP, or other academic and research institutions. An incentive scheme must be provided to encourage the coming of experts from Manila to Mindanao.

**ON ENCOURAGING TECHNOLOGY-FOCUSED CAPABILITIES**

Our high school graduates should be encouraged to attain functional literacy and technology-focused capabilities. To accomplish this, more efforts must be exerted to force a shift in the inclination of our high school graduates from taking degrees leading to white collar jobs to those leading to blue collar courses which are in greater demand by the industries.

For example, we find it sad to note that even the teaching of industrial arts in the elementary grades had been stopped. We certainly think that reviving the teaching of this subject to our youth will be a step in the right direction.

**ROSITA V. FUNDADOR, Ph.D.**

*Director, Philippine Science High School  
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8000 Davao City*

Mindanao has several advantages over the other regions in the country. It still has the rich natural resources which substantially contribute to 60% of the national budget. The area is less prone to natural calamities like earthquakes and typhoons. Mindanao has another competitive advantage: its human resource. It is said that human resource is the most valuable resource. Unlike other resources which can be depleted in the course of time and use, human resource continues to grow, no matter how much of it is used. Any investment, therefore, on human resource is an investment of a lifetime. We often hear of synergism, which, put in simple terms is the whole being greater than the sum of its parts. The concerted efforts of a variety of manpower skills then becomes a definite advantage to a nation that intends to join the world's new economic giants. It is therefore imperative that this vital resource be harnessed to fill in the growing demand for an educated and skilled labor force to man the BIMP-EAGA economic development plan.

The current educational systems needs to be redirected to conform with the present trend towards industrialization in Mindanao. For a nation that is moving towards industrialization, there are two objectives that must be pursued: people empowerment and global competitiveness. People empowerment is having access to quality basic education, i.e., elementary and secondary education. Empowered people are individuals who have the knowledge, skills, desire, and opportunity to personally succeed in any endeavor in life. An empowered people exercise effective control over every aspect of their lives. Nowadays, we commonly see the slogan "Quality Education for Philippines 2000" boldly written on the roofs and walls of public school buildings. It is a recognition that quality education is the vehicle towards the realization of our goal for Philippines 2000. But quality basic education goes beyond just providing the 3R's, facts, and knowledge to the students. More importantly, it should be able to teach the young how to access information. Quality education should also provide for the acquisition of communication and social skills and entrepreneurship which are needed to survive in this fact-changing world. It should also promote a science and technology culture which will increase public awareness and appreciation of the usefulness of science and technology in everyday life. We need to teach people, especially ordinary Filipinos, to use technology to enhance their skills and optimize productivity, thereby improving their lifestyle. Along this line, Science as a subject is now reintroduced in Grades 1 and 2. Contact hours have been increased for English, Science, and Mathematics in the elementary and high school. Competence of elementary and secondary teachers handling these subjects is being upgraded. An integrated or multidisciplinary approach in teaching is being promoted to provide a wholistic education to our populace, one which is responsive to the needs of the time.

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Mindanao has several advantages over the other regions in the country. It still has the rich natural resources which substantially contribute to 60% of the national budget. The area is less prone to natural calamities like earthquakes and typhoons. Mindanao has another competitive advantage: its human resource. It is said that human resource is the most valuable resource. Unlike other resources which can be depleted in the course of time and use, human resource continues to grow, no matter how much of it is used. Any investment, therefore, on human resource is an investment of a lifetime. We often hear of synergism, which, put in simple terms is the whole being greater than the sum of its parts. The concerted efforts of a variety of manpower skills then becomes a definite advantage to a nation that intends to join the world's new economic giants. It is therefore imperative that this vital resource be harnessed to fill in the growing demand for an educated and skilled labor force to man the BIMP-EAGA economic development plan.

The current educational systems needs to be redirected to conform with the present trend towards industrialization in Mindanao. For a nation that is moving towards industrialization, there are two objectives that must be pursued: people empowerment and global competitiveness. People empowerment is having access to quality basic education, i.e., elementary and secondary education. Empowered people are individuals who have the knowledge, skills, desire, and opportunity to personally succeed in any endeavor in life. An empowered people exercise effective control over every aspect of their lives. Nowadays, we commonly see the slogan "Quality Education for Philippines 2000" boldly written on the roofs and walls of public school buildings. It is a recognition that quality education is the vehicle towards the realization of our goal for Philippines 2000. But quality basic education goes beyond just providing the 3R's, facts, and knowledge to the students. More importantly, it should be able to teach the young how to access information. Quality education should also provide for the acquisition of communication and social skills and entrepreneurship which are needed to survive in this fact-changing world. It should also promote a science and technology culture which will increase public awareness and appreciation of the usefulness of science and technology in everyday life. We need to teach people, especially ordinary Filipinos, to use technology to enhance their skills and optimize productivity, thereby improving their lifestyle. Along this line, Science as a subject is now reintroduced in Grades 1 and 2. Contact hours have been increased for English, Science, and Mathematics in the elementary and high school. Competence of elementary and secondary teachers handling these subjects is being upgraded. An integrated or multidisciplinary approach in teaching is being promoted to provide a wholistic education to our populace, one which is responsive to the needs of the time.



**PLENARY SESSION III**  
**“THE USE OF MINDANAO’S LAND,  
RESOURCES, AND ENVIRONMENT FOR ITS  
DEVELOPMENT”**

**The Use of Mindanao’s Land, Resources, and  
Environment for Its Development**

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**I. INTRODUCTION**

Land, resources, and environment are necessary factors for economic development. Countries with abundant land and natural resources often have their economic development facilitated by judicious exploitation of those resources. In general, countries that used a major portion of their resources for investment, i.e., for productive uses and for resources regeneration and conservation, attained the highest level of economic development. Countries, however, that exploit their natural resources disproportionately for consumption remain generally underdeveloped or unable to sustain their level of development. This generalization is not often applied on a sub-national framework simply because of the difficulty of establishing a set of rules wherein a sub-national entity could control the use of its own resources for its development. Alternatively, the investors who exploit a sub-national resource endowment often are not residents of the region. Consequently, a large portion of the revenues from the exploitation of sub-national resources is not retained by the region. Instead, it used to develop the outside economy or used to purchase consumption goods outside the area.

This paper is not to explain the relative underdevelopment of Mindanao vis-a-vis Luzon via an irrational resource exploitation argument or by applying the dependency theory.<sup>1</sup> It will attempt to assess, however, (a) the potential of Mindanao in terms of its own food security, (b) the rational use including the regeneration and conservation of the forest resource of Mindanao, (c) the potential of the known

<sup>1</sup>See for example: A.G. Frank, *Capitalism and Underdevelopment in Latin America*. Pelican, London, 1967. For a review of the theory and its critique see: D.K. Forbes. *The Geography of Underdevelopment*. Croom Helm, London and Sydney, 1984.



mineral and related resources of the island, and (d) current status and potentials of the fresh and marine resources of Mindanao. The paper is divided into five sections. After the introductory part, section two reviews the state of Mindanao's resources using available data. Section three provides a theoretical framework for the utilization of Mindanao's resources. Section four assesses the food security and economic potentials of the resources of Mindanao, and the last section gives the summary and conclusion of the study.

## 2. LAND AND NATURAL RESOURCES OF MINDANAO

This section presents the state of Mindanao land, natural resources, and environment. To be able to gauge the state of land and natural resources of Mindanao, it is best to use two time periods, i.e., an earlier time period serving as a benchmark. It was found out, however, that government statistics are not consistent over the years. Consequently, the use of two time periods is difficult to apply in some variables.

This section relied heavily on the following reports: "Crop Development and Soil Conservation Framework for Mindanao", a study conducted by the Bureau of Soils and Water Management in 1980; Philippine Forestry Statistics published by the Forest Management Bureau of the Department of Environment and Natural Resources, and statistical yearbooks and development plans of the Regional Development Councils of Mindanao.

### 2.1 Land Resources<sup>2</sup>

The total land area of Mindanao is 10,199,885 hectares. In 1993, about 4.13 million hectares of the Mindanao land area were classified alienable and disposable. Forest land consisted of about 5.73 million hectares of classified forest and 338.7 thousand hectares of unclassified forest. Table 1 presents the land use pattern in Mindanao in 1993.

The status of land and forest resources will be discussed separately.

#### 2.1.1 Land classes

The Bureau of Soils and Water Management evaluation of the land resources of Mindanao includes its environmental dimension, i.e., landscape, elevation, slope, and temperature. Land resources under this evaluation are classified into different pedo-ecological zones. This classification allows the selection of a sustainable land use over time. Table 2 presents the land resources of Mindanao classified into pedo-ecological zones.

Table 2 reveals that about 18.4 percent of the total land area of Mindanao or about 1.87 million hectares are classified as warm lowland. These lands consist of

<sup>2</sup>Unless otherwise stated, this section is based on the report of the Bureau of Soils and Water Management, see: Bureau of Soils and Water Management, *Crop Development and Soil Conservation Framework for Mindanao Island*, Quezon City, 1990.

**Table 1. Land resource and land use in Mindanao, 1993 (in hectares)**

Region	Total Land Area	Certified A and D	Forest Land Classified	Forest Land Unclassified
Region IX	1599734	762252	810611	26871
Region X	2832774	1066931	1715111	50734
Region XI	3169275	1212440	1840061	116774
Region XII	1437274	546828	840815	49631
ARMM	1160829	542827	523329	94673
Mindanao	10199885	4131278	5729927	338681
Philippines	3000000	14117244	15001599	881157

Source: DENR, Forest Management Bureau, *1993 Philippine Forest Statistics*, Quezon City, Metro Manila, 1993.

**Table 2. Land classification by pedo-ecological zone, by region (in hectares)**

Pedo-ecological Zone	Region IX	Region X	Region XI	Region XII	Total	Per-cent
Warm lowland	485578	364279	503532	522816	1876205	18.39
Warm cool upland	523635	672902	457046	299767	1953352	19.15
Warm cool hillyland	670992	685363	966247	617150	2939752	28.82
Cool highland	173787	1065234	1160881	824732	3224634	31.61
Miscellaneous land type	14518	44992	81584	64853	205947	2.02
<b>TOTAL</b>	<b>18678510</b>	<b>2832770</b>	<b>3169290</b>	<b>2329320</b>	<b>1019989</b>	<b>100.00</b>

Source: ALMED, Bureau of Soils and Water Management.

areas within 100 meters elevation with slopes not exceeding 8 percent. The average temperature of this zone is greater than 25 degrees Celsius. Land under the warm lowland zone is devoted to food crops, especially irrigated rice. It is also the zone where human settlements are often found. Consequently, land under this zone is also utilized for non-agricultural uses such as residential areas, industrial sites,

and for social and support infrastructures. Regions XI and XII<sup>3</sup> exhibit the largest land area under the warm lowland zone.

The warm-cool upland zone occupies an estimated 1.95 million hectares or about 19.2 percent of the total land area of Mindanao. This zone has a slope of not more than 18 percent and an elevation not exceeding 300 meters. The average temperature of this zone ranges from 22.5 to 25 degrees Celsius. This zone provides a favorable upland agricultural production enterprise for Mindanao, but faces the problem of soil erosion. Annual and perennial crops are planted in the warm-cool upland zone. It needs, however, appropriate cultural practices and the right crop mix to maintain the zone's productivity. Region X exhibits the largest area under the warm-cool upland zone with 672,902 hectares followed by Region IX with 523,635 hectares (Table 2).

The warm-cool hillyland zone comprises about 2.94 million hectares or about 28.8 percent of the total land area of Mindanao. This zone is located within the 500 meters elevation and slope of more than 18 percent. The average temperature of this zone is similar to the warm-cool upland zone. The vegetative cover of this zone consists of forest along the seepage areas and grassland on the expose convex portion of the landscape. This zone is ecologically fragile. This is because it is prone to soil erosion and land degradation. In regions where lowland resources are limited, the problem of soil erosion and land degradation becomes severe as this zone is subjected to shifting agriculture. This zone needs an intensive soil conservation program and forest conservation and protection. Economic utilization of the warm-cool hillyland zone should focus on tree crops and forest trees or crops that provide more soil cover and do not require intensive cultivation. Region-wise, the largest area under the warm-cool hillyland is found in Southern Mindanao with 966,247 hectares followed by Northern Mindanao with 685,363 hectares.

The cool-highlands zone occupies 31.61 percent to the total land area of Mindanao and consists of land areas with an elevation of 500 meters and higher. Lands under this zone have slopes ranging from flat to extremely steep. They have generally stable temperatures with available moisture to allow an effective year-round bio-mass production. Areas under this zone, when not constrained by topography and soils, are well suited for the production of fruits, vegetables, and cut flowers. They are also suited for the establishment of summer resorts and tourism projects. The attainment of the socio-economic potentials of the cool-highlands zone requires an optimum interplay of resource conservation, resource regeneration, and economic exploitation activities. Southern Mindanao has the largest land area under the cool highland zone with 1,160,881 hectares followed by Northern Mindanao with 1,065,234 hectares (Table 2).

<sup>3</sup>Regional delineation used in this paper follows the old system, i.e., ARMM and the Caraga region are imbedded in the four regions of Mindanao.

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### 2.1.2 Land use and vegetative cover

The present land use and vegetative cover of the different pedo-ecological zones by regions of Mindanao are presented in Table 3.

The total agricultural area in Mindanao across four pedo-ecological zones is about 3,439.44 thousand hectares or about 34 percent of the total land area of the island. Of the total agricultural areas, about 38 percent are located in the warm lowland zone. It is in the agricultural areas that intensive agricultural production and infrastructural areas that intensive agricultural production and infrastructures such as roads, bridges, ports, and irrigation systems are located. Grasslands/shrubland areas of Mindanao are estimated at 2,951.34 thousand hectares or about 29 percent of the total Mindanao land area. They are concentrated in the hillyland and highland zones which together account for about 76 percent of the total grassland/shrubland areas of Mindanao. Woodland or forested areas account for about 32 percent of the Mindanao land area. These areas are primarily covered with trees or dominated by woody type vegetation. Woodland areas are areas that should be permanently retained under forest cover.

Wetland areas represent a little over 3 percent of the total Mindanao area. Mangroves and nipa areas account for 35.5 percent of the total wetland areas. Included also in the wetland areas are fishponds, saltbeds, and fresh water swamps. Wetland areas, particularly the mangrove areas, serve as the breeding ground for marine animals, as well as being an important source of food.

**Table 3. Land use and vegetative cover by pedo-ecological zone in Mindanao (in thousand hectares)**

Land Use/ Vegetation	Warm Low- land	Warm Cool Upland	Warm Cool Hilly- land	Cool High- land	Miscel- laneous Type	Total	Per- cent
Agricultural areas	1296.29	1171.92	536.05	435.17		3439.44	33.72
Grassland/ Shrubland areas	188.15	506.3	1236.39	1020.46		2951.34	28.93
Woodland areas	57.87	275.10	1167.31	1768.99		3269.27	32.05
Wetland areas	333.89					333.89	3.27
Miscellaneous areas					205.95	205.95	2.02
<b>TOTAL</b>	<b>1876.21</b>	<b>1953.35</b>	<b>2939.75</b>	<b>3224.63</b>	<b>205.95</b>	<b>10199.9</b>	<b>100.00</b>

Source: ALMED, Bureau of Soils and Water Management.

Miscellaneous areas cover those under kaingin, which in Mindanao is estimated to occupy about 205,947 hectares or 2.02 percent of the Mindanao area; built-up areas; major rivers and other bodies of water; barren lands; river wash and bars; mines and quarries; and infrastructures such as roads, bridges, and airfields.

### 2.1.3 Land availability

The arable land of Mindanao, i.e., agricultural areas plus agricultural expansion areas, is estimated at 5,479,681 hectares or approximately 54 percent of the total land area of the island. The remaining 46 percent of the total area or 2,948,208 hectares are categorized as preservation areas, i.e., land that requires protection. These preservation areas include: the rehabilitation areas of 1,231,159 hectares; preservation areas of 2,949,208 hectares; wetland areas of 333,895 hectares; and miscellaneous areas of 205,947 hectares (Table 4).

The BSWM study reported that about 61 percent of the total agricultural lands in Mindanao are already utilized for various agricultural activities. The remaining 39 percent are still not yet fully tapped and therefore available for future agriculture production activities. Region-wise, the largest share of arable land is exhibited by Region XI with 1,869,393 hectares followed by Region X with 1,432,676 hectares. Region IX, on the other hand, has 1,221,616 hectares of arable land, while Region XII exhibited the lowest arable land with 955,996 hectares.

**Table 4. Land use opportunity by region, Mindanao (in hectares)**

Land Use Opportunity	Region IX	Region X	Region XI	Region XII	Total Area	Percent of Total
Agricultural areas	762928	8637976	1103000	617544	3347268	32.82
Agricultural expansion areas	458688	568880	766393	338452	2132413	20.91
Rehabilitation areas	179944	308957	260102	482156	1231159	12.07
Preservation areas	343369	969925	923598	712317	2949208	28.91
Wetland areas	109064	76220	34613	113998	333895	3.27
Miscellaneous areas	14518	44992	81584	64853	205947	2.02
<b>TOTAL</b>	<b>1868510</b>	<b>2832770</b>	<b>3169290</b>	<b>2329320</b>	<b>10199890</b>	<b>100.00</b>

Source: ALMED, Bureau of Soils and Water Management.

BSWM reported that Region XII has already utilized about 65 percent of its arable land. Future expansion of agricultural activities in Region XII will have to contend with the remaining 333,452 hectares of arable land. Future expansion of agriculture production in Region IX will be limited by the remaining arable land estimated at 37.5 percent of the region's arable area. This is because Region IX has already utilized 62.5 percent of its arable land.

By and large, Regions X and XII present significant potentials for future expansion of agricultural production areas. These two regions exhibited the largest share of arable lands and in 1989 Region X had still 568,880 hectares of arable land not fully utilized, while Region XI had in store 766,393 hectares for future expansion of agricultural areas.

#### 2.1.4 Land degradation

Soil fertility and consequently its productivity is diminished by land degradation. The most common and perhaps also the most critical form of soil degradation in the Philippines is soil erosion. It is estimated that about 50 percent of the total land area of Mindanao is suffering from various degrees of soil erosion. Table 5 presents the soil erosion statistics for Mindanao.

Table 5 shows that about 28 percent of the total land area of Mindanao is suffering from moderate erosion, while 22 percent is severely eroded. Region-wise, Northern Mindanao has 53.8 percent of its total area affected by moderate and severe erosion, about 21 percent of the region's area is suffering from severe erosion. Central Mindanao, on the other hand, has 50.3 percent of its area affected by moderate and severe erosion with the latter accounting for about 20 percent.

Table 5. Soil erosion, by region, Mindanao (in hectares)

Region	Area	Moderate	Severe	Total	Percent of Region
Western Mindanao	1868510	70516	212343	917459	49.10
Northern Mindanao	2832770	920531	603451	1523982	53.80
Southern Mindanao	3169290	574977	966174	1541051	48.62
Central Mindanao	2329320	706767	464960	1171727	50.30
TOTAL	10199890	2907291	2246926	5154219	
Percent of					
Total		28.50	22.03	50.53	

Source: ALMED, Bureau of Soils and Water Management.

Western Mindanao and Southern Mindanao have less than 50 percent of their area affected by moderate and severe erosion. Western Mindanao, however, registered only 11.36 percent of its total land area as severely eroded, while Southern Mindanao has 30.49 percent of its area affected by severe erosion.

The effects of soil erosion, among others, are manifested by the physical loss of the top soil and loss of soil nutrients needed for plant growth. The latter is manifested by the reduction of productivity or yield per unit area. An estimate of such yield reduction on certain crops can be translated to monetary terms and therefore an estimate of the cost of soil erosion via the forgone output. Data on reduction in yield due to soil erosion are not available. The BSWM study, however, estimated the volume of soil loss per region. Table 6 presents a summary of the BSWM result.

Table 6 shows that Mindanao is losing annually a sizeable amount of soil because of soil erosion. The estimated aggregate annual soil loss by erosion by region ranges from a low of 18,809,213 metric tons for Western Mindanao to a high of 141,735,448 metric tons for Central Mindanao. As a whole, the average annual soil loss due to erosion in Mindanao is estimated at 29.21 metric tons per hectare per year or a total of 297,935,280 metric tons for the whole island.

## 2.2 Forest Resources of Mindanao

Two measures are often used to determine forest resources. The first one is in terms of forest area, i.e., in hectares or in square kilometers. The other is by the volume of standing stock of trees. This section will present these two measures to assess the forest resources of Mindanao.

### 2.2.1 *Forest land*

Table 7 presents the forest land in Mindanao under both classified and unclassified categories.

In 1993, the total forest area of Mindanao was placed at 8068.5 thousand hectares. Of this total, 338.7 thousand hectares were unclassified forest and 5729.9 thousand hectares were classified forest. The classified forest is subdivided into Established Forest Reservation with 1104.2 thousand hectares; Timberland with 4318.4 thousand hectares; National Parks with 164.4 thousand hectares; Military and Naval Reservations with 8.05 thousand hectares; Civil Reservation with 88.7 thousand hectares; and Fishponds with 26 thousand hectares. Region-wise, Southern Mindanao registered the largest forest area accounting for 32 percent of the total forest area of Mindanao followed by Northern Mindanao with 29 percent and Central Mindanao with 15 percent. The lowest forest area is exhibited by ARMM with 837,482 hectares or 10 percent of the total forest area of Mindanao. Southern Mindanao has also the largest established timberland area with 1,546.7 thousand hectares or 36 percent of the total established timberland, while Northern Mindanao is second with 1,327.0 thousand hectares or 31 percent of the total timberland area of Mindanao.



**Table 6. Estimated volume of soil loss, by region, Mindanao**

Region	Description	Total Area	Percent	Average Soil Loss (mt/ha)	Total Soil Loss (mt)	Percent of Mindanao
Western Mindanao	Eo	354500	18.97			
	E1	582033	31.15	2.54	1478364	0.50
	E2	705116	37.74	8.10	5711440	1.92
	E3	212343	11.36	54.72	1161949	3.90
	Sub-total	1868510	100.00	65.36	188909213	6.32
Northern Mindanao	Eo	330216	11.66			
	E1	964821	34.06	4.60	4438177	1.49
	E2	920531	32.50	17.50	16109293	5.41
	E3	603451	21.30	61.50	37112237	12.46
	Eu	13751	0.48			
Sub-total	2832770	100.00	83.60	57659707	19.36	
Southern Mindanao	Eo	529049	16.69			
	E1	1090510	34.40	12.40	13522324	4.54
	E2	574677	18.14	18.70	1075020	3.61
	E3	966174	30.49	30.49	55458300	18.61
	Eu	8630	0.28			
Sub-total	31692901	100.00	88.50	79730912	26.76	
Central Mindanao	Eo	595698	25.57			
	E1	549128	23.58	4.50	2471076	0.82
	E2	706767	30.34	50.80	35903764	34.69
	E3	464960	91.96	222.30	103360608	34.69
	Eu	12767	0.55			
Sub-total	2329320	100.00	277.60	141735448	47.56	
GRAND TOTAL		10199890			297935280	100.00

Source: ALMED, Bureau of Soils and Water Management.

### 2.2.2 Volume of timber in forestland

The volume of timber is obviously a better measure to gauge the forest resource. In particular, if taken at two different points of time, the measure will give an indication on the effectiveness of the government policy on sustainability. Unfortunately, statistics in the Philippines on the volume of timber are not consistent enough to allow a precise analysis of the changes that occurred in the forest resources. For example, the 1978 Philippine Forestry Statistics presented a table on

**Table 7. Forest land, category, Mindanao, 1993**  
(in thousand hectares)

Mindanao/Region	Grand Total	Un-classified	Total Classified	Reservation	Established Timberland	National Parks	Military and Naval Reservations	Civil Reservations	Fishponds
Western Mindanao	837.5	26.9	810.6	424.9	370.3	2.6	0.05	2.6	10.1
Northern Mindanao	1765.8	50.7	1715.1	314.8	1327.0	55.7	-	6.2	11.4
Southern Mindanao	1956.8	116.8	1840.1	217.8	1546.7	53.6	-	19.1	2.7
Central Mindanao	890.4	49.6	840.8	122.3	608.7	20.6	8.0	60.8	0.5
ARMM	618.0	94.7	523.3	24.4	465.7	31.9	-	-	1.3
Mindanao	6068.5	338.7	52729.9	1104.2	4318.4	164.4	8.05	88.7	26.0

Source: DENR, Forest Management Bureau, *1993 Philippine Forest Statistics*, Quezon City, Metro Manila, 1993.

volume of timber in forestland which divided the forest into productive and non-productive, with the productive forest further subdivided into Dipterocarp and Mangrove and, under Dipterocarp and Mangrove, trees are classified into Rep. Brush, Young Growth, and Old Growth. The 1993 Philippine Forestry Statistics no longer carry the 1978 presentation. What is presented is the volume of timber in commercial forest which is subdivided into Dipterocarp, Residual, and Pine. Under Dipterocarp and Pine are: Common Hardwoods, Construction and Furniture Woods (CFW), Softwoods, and Others. This paper presents the 1978 and 1993 volumes of timber statistics separately.

To relate Tables 8 and 9, the discussion focuses only on productive forest, a category that perhaps is approximated by commercial forest Dipterocarp. In 1978, the total volume of Mindanao's Dipterocarp was estimated at 856,255 thousand cubic meters or about 58 percent of the Philippines Dipterocarp in terms of volume. Mindanao also accounted for about 68 percent or 352,458 thousand cubic meters of Dipterocarp young growth and about 55 percent of total volume of old growth. Mindanao accounted for about 46 percent of the total volume of Mangrove in the Philippines. About 81 percent of the standing volume of Mangrove in Mindanao in 1978 was accounted for by young growth, with old growth contributing only about 13 percent (Table 8).

After 15 years, the volume of Dipterocarp in Mindanao has gone down from 835,999 thousand cubic meters in 1978 (young plus old growth) to 160,767 thousand cubic meters (commercial Dipterocarp) in 1993 and from 483,541 thousand cubic meters (old growth) in 1978 to 160,767 thousand cubic meters in 1993. These figures imply that volume of commercial Dipterocarp in 1993 was 19 percent of the volume of young and old Dipterocarp in 1978 or 33 percent of the volume of old growth Dipterocarp in 1978 (Tables 8 and 9).

### 2.2.3 *Trend of log production and export*

Total log production in the Philippines was 10,446 thousand cubic meters in 1972-73. Since then, there was a steady decline in log production in the country so that by 1993 production of logs was down to 1,022 thousand cubic meters. The grand total roundwood production (log production plus fuelwood/firewood) for the same period was 10,461 thousand cubic meters and 1,152 thousand meters respectively. The available data for Mindanao placed log production for 1993 at 935 thousand cubic meters.

Log production in the Philippines declined drastically during the 1973 to 1993 period. In 1973, log production in the country was placed at 10,461 thousand cubic meters, this dropped to 1,152 thousand cubic meters in 1993. The annual decline of log production over the same period is -9.99 percent.<sup>4</sup> Time series data on log production in Mindanao during the 1973 to 1993 period are not available, however,

<sup>4</sup>All annual growth rates in this paper are estimated using the equation  $\ln Y_t = a + b \cdot t$ .

**Table 8. Volume of timber, Mindanao, 1978 (in thousand cubic meters)**

Item	Philippines	Mindanao	Percent of Philippines
I. Productive Forest	1501722	859214	57.21
1. Dipterocarp	1477347	856255	57.96
a. Rep. brush	76996	20256	26.31
b. Young growth	519612	352458	67.83
c. Old growth	880739	483541	54.90
2. Mangrove	7468	3459	46.32
a. Rep. brush	1198	213	17.78
b. Young growth	4762	2800	58.80
c. Old growth	1508	446	29.57
3. Pine	16907	--	0
II. Unproductive Forest	121865	21042	17.27
1. Diptorecarp	106771	15946	14.93
2. Mossy	15094	5096	33.76

Source: DENR Forest Management Bureau, *1978 Philippine Forestry Statistics*, Quezon City.

**Table 9. Volume of timber in commercial forest, Mindanao, 1993 (in thousand cubic meters)**

Forest Type/Commercial Group	Philippines	Mindanao	Percent of Philippines
Total	447857	160769	35.90
Dipterocarp. residual	423480	160769	37.96
Common hardwoods	214159	41460	29.79
CFW	139149	41460	29.79
Softwoods	7453	5902	79.19
Others	62719	23773	37.90
Pine	24377	--	--
Common hardwoods	101	--	--
CFW	32	--	--
Softwoods	24194	--	--
Others	50	--	--

Source: DENR Forest Management Bureau, *1993 Philippine Forestry Statistics*, Quezon City, 1993.

Mindanao produces a sizeable portion of the total log production of the country. Thus, in 1993, Mindanao's log production was placed at 935 thousand cubic meters or about 81 percent of the total log production of the country for the same year (Table 10).

Parallel with the decline in log output is the rapid drop of log export of the Philippines. In 1973, log export of the country was a high of 6,956 thousand cubic meters; this dropped to about one thousand cubic meters in 1993. Log export of the country over the same period decreased at an annual rate of -39.38 percent. With the declining log production, the forestry sector could no longer satisfy domestic demand. Thus, starting with a 10 thousand cubic-meter-log-import in 1968, importation of logs accelerated rapidly such that in 1993 it registered 1066 thousand cubic

**Table 10. Log production and export, Philippines, 1973 to 1993**  
(in thousand cubic meters)

Year	Production	Export	Import (Logs + Lumber)	Mindanao Log Production
1973	10461	6956		
1974	10214	5446		
1975	11913	6841		
1976	8729	2332		
1977	7951	2047		
1978	7246	2211		
1979	6773	1248		
1980	6462	758		
1981	5542	706		
1982	4674	807		
1983	4545	903		
1984	4280	996		
1985	3588	653		
1986	3588	412		
1987	4253	205		
1988	3893	174	10	
1989	3217	110	410	
1990	2596	51	385	
1991	2141	2	405	
1992	1757	-	573	
1993	1152	1	166	935
Percent annual increase	-9.99	-39.38	79.71	

Source: DENR Forest Management Bureau, 1993 *Philippine Forestry Statistics*, Quezon City, 1993.

meters. From 1988 to 1993 therefore log importation registered an annual growth rate of 69.71 percent.

#### 2.2.4 *Reforestation program*

Both the government and the non-government sectors are engaged in reforestation to replace the trees that had been cut or harvested. As of 1993, the total area planted by both sectors is placed at 1,375,619 hectares. The aggregate area planted by the government, during the period from 1960 to 1993, is placed at 954,551 hectares or about 69 percent of the total. The non-government sector, on the other hand, reforested a total of 421,068 hectares of which 77 percent is accounted for by the timber licensees from 1976 to 1993. Reforestation data for the whole of Mindanao in 1993 placed the area reforested by both the government and private sectors at 13,640 hectares. Of the total area reforested in Mindanao in 1993 about 82 percent or 11,230 hectares are accounted for by the private sector.<sup>5</sup>

### 2.3 Mineral Resources

This section presents the available estimates of both metallic and non-metallic ore reserves of Mindanao. There is reason to believe that the data underestimated the true mineral deposit of Mindanao since it may not be reasonable to assume that Central Mindanao has no metallic ore deposits. The available data revealed low non-metallic ore deposits in Mindanao compared to the rest of the country, except magnesite of which Mindanao appeared to account for almost the entire deposit of the country, i.e., 99.99 percent. On the other hand, it is also possible that the present estimates need updating. For example, the Bureau of Mines and Geo-sciences reported only about 4.5 million metric tons of clay in the whole Mindanao or only about 0.41 percent of the clay, silica rockform, and sulfur deposits of the country.

Nevertheless, available data on metallic ore deposits of Mindanao revealed great potential for development. For example, Mindanao accounts for about 48 percent of the total estimated gold deposits of the Philippines. A large portion of Mindanao's estimated gold deposits are found in Southern Mindanao and Northern Mindanao regions which account for 48 percent and 47 percent respectively of the total Mindanao deposits (Table 11). About sixty three (63) percent of the country's nickel deposits are found in Mindanao. Northern Mindanao and Southern Mindanao regions also account for the entire nickel deposits in Mindanao with the former representing 51 percent and the latter, 49 percent. Chromite and copper deposits in Mindanao account for about 9 and 7 percent respectively of the total Philippine deposits for these two metals. Almost all Mindanao deposits of copper are found in Southern Mindanao. The same holds true for chromite deposits in Northern Mindanao.

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<sup>5</sup>See: Table 1.09, DENR Forest Management Bureau, *1993 Philippine Forestry Statistics*, Quezon City, Philippines, 1993.

**Table 11. Estimated metallic ore reserves of Mindanao  
(in thousand metric tons)**

Region	Gold	Copper	Chromite	Iron	Nickel	Others
Western Mindanao	2247	137	2	3150	0	5952
Northern Mindanao	23841	0	2495	0	515129	292028
Southern Mindanao	24319	284103	64	6000	489719	0
Central Mindanao	0	0	0	0	0	0
Mindanao	50407	284240	2561	9150	1004848	297980
Philippines	104140	4303776	30200	180342	1592085	346572
Mindanao as percent of Philip- pines	48.4	6.6	8.5	5.1	63.1	85.9

Source: Bureau of Mines and Geo-Sciences.

The National Statistics Office 1994 Philippine Year Book reported that gold production in Mindanao dropped from 1,753 kilograms in 1990 to 1,544.67 kilograms in 1991. These figures do not include the 458.852 (SSM) kilograms of gold produced in 1990 and the 247.47 (SSM) kilograms of gold produced in 1991. Nickel production also decreased from 6,036 mt in 1990 to 1,227 mt in 1991. The same decline in production was experienced in copper and copper concentrate production. The former dropped from 10,881 mt in 1990 to 7,603 mt in 1991, while the latter declined from 42,623 dmt in 1990 to 31,858 dmt in 1991. Metallurgical chromite, on the other hand, increased from 25,623 dmt to 37,186 dmt in 1991.

## 2.4 Fisheries

The discussion on the fisheries of Mindanao covers only commercial, municipal, and aquaculture. The focus of the discussion will be on the trend of fish production on these three types of fishing from 1979 to 1988. The total fish production of Mindanao in 1988 was 761,879 metric tons, a nearly 80 percent increase from the 1979 fish production of 424,121 metric tons. The annual growth rate of aggregate fish production of Mindanao for the same period is 6.53 percent.

### 2.4.1 Commercial fishing

Commercial fish production in Mindanao increased from a low of 79,526 metric tons in 1979 to a high of 131,666 metric tons in 1988. These translate to an annual growth rate of 6.51 percent over the same period. Western Mindanao accounted for about 65 percent of the total commercial fish output of Mindanao in 1979; this share dropped to about 63 percent in 1988. A far second to Western Mindanao in commercial fish production is Southern Mindanao. In 1979, Southern Mindanao commercial fish output accounted for 31 percent of the total commercial output of Mindanao. This share increased to 32 percent in 1988. In terms of annual growth rate, Northern Mindanao registered the highest with 10 percent followed by Southern Mindanao with about 8 percent, and Western Mindanao with about 6 percent. Commercial fish production in Central Mindanao registered an annual decline of -14 percent over the same period (Table 12).

### 2.4.2 Municipal fishing (marine and inland)

Municipal fishing covers both marine and inland. In 1979, municipal fish production in Mindanao was placed at 228,647 metric tons. This increased to 453,445 metric tons in 1983 and declined to 366,531 metric tons in 1988. Over the 1979 to 1988 period, municipal fish output of Mindanao registered an annual growth rate of 5 percent. The highest annual growth rate in municipal fish production is observed

Table 12. Commercial fishing production, by region, Mindanao, 1979 to 1988  
(in metric tons)

Year	Western Mindanao	Northern Mindanao	Southern Mindanao	Central Mindanao	Mindanao
1979	51300	2520	24500	1200	79526
1980	44243	3105	22948	1226	71521
1981	55601	4005	24466	605	84677
1982	67843	4295	27471	785	100394
1983	64427	5027	27639	1015	98108
1984	65766	5735	34982	707	107190
1985	70185	6030	42799	343	119357
1986	72808	6210	38944	349	118311
1987	79752	6397	38819	351	125319
1988	82310	6293	42663	420	131686
Growth rate (%)	5.97	10.08	7.61	-14.42	6.51

Source: BAS. DA. *Selected Fishery Statistics, 1979-1988*.



in Western Mindanao with about 8 percent followed by Northern and Southern Mindanao regions with about 5 percent annual growth rates. Central Mindanao region registered an annual growth rate of -1.49 percent over the same period. Western Mindanao accounted for about 40 percent of the total municipal fish production in 1979. This share of the region increased to about 54 percent of the total municipal fish production of Mindanao in 1986. The other three regions of Mindanao registered declining shares of the total municipal fish output over the same period with Northern Mindanao showing the greatest decline from 26 to 20 percent, followed by Central Mindanao with a drop from 16 to 11 percent and Southern Mindanao from 18 to 15 percent (Table 13).

### 2.4.3 Aquaculture fish production

Aquaculture fish production in Mindanao registered an output of 115,748 metric tons in 1979. This increased to 263,662 metric tons in 1988. The annual growth rate of aquaculture fish production over the 1979 to 1988 period is a little over 9 percent. The center of aquaculture fish production in Mindanao is Western Mindanao Region. In 1979, Western Mindanao accounted for 93 percent of the total aquaculture fish output of Mindanao. This share of the region increased to 94 percent in 1988 (Table 14).

Aquaculture fish production exhibited varying annual growth rates among the four regions of Mindanao. The highest annual growth rate is registered by Southern Mindanao with 14 percent followed closely by Western Mindanao with

**Table 13. Municipal fish production, by region, Mindanao, 1979 to 1988 (metric tons)**

Year	Western Mindanao	Northern Mindanao	Southern Mindanao	Central Mindanao	Mindanao
1979	92194	5930	41591	35432	228847
1980	109427	53773	35814	53330	252144
1981	154092	56239	36089	53122	299542
1982	168332	59223	32736	48664	308955
1983	199702	65764	34813	153166	453445
1984	201254	74420	32196	61617	369487
1985	209628	76470	35765	46962	368825
1986	193082	722757	54678	55263	375789
1987	196335	77821	54318	38013	366487
1988	196462	75334	56284	38451	366531
Growth rate (%)	7.69	4.61	4.81	-1.49	5.04

Source: BAS, DA, *Selected Fishery Statistics, 1979-1988*.

**Table 14. Aquaculture fish production, by region, Mindanao, 1979 to 1988  
(metric tons)**

Year	Western Mindanao	Northern Mindanao	Southern Mindanao	Central Mindanao	Mindanao
1979	107801	2322	2336	3289	115748
1980	122145	2393	2390	3340	130468
1981	89533	2473	4590	4427	101023
1982	95278	2473	4776	5231	107758
1983	115808	1723	7453	4039	129023
1984	127220	3375	6981	3894	141380
1985	163771	2798	6765	3958	177292
1986	160363	2606	6235	3735	172939
1987	216464	3178	7344	3692	230678
1988	247319	3463	8892	3988	263662
Growth rate (%)	9.76	4.17	13.56	0.43	9.49

Source: BAS, DA, *Selected Fishery Statistics, 1979-1988*.

10 percent. Northern Mindanao registered 4 percent annual growth rate over the same period, while Central Mindanao exhibited a meager annual increase of 0.4 percent.

## 2.5 Roads and Irrigation Systems

### 2.5.1 Road network

Access to markets is generally indicated by the presence of adequate infrastructures to facilitate movements of farm inputs and farm products to producers and consumers. One of the indices often used by planners to measure such adequacy is the road density, i.e., the number of kilometers of road per square kilometer of land. Thus, one kilometer of road per square kilometer of land is generally considered optimum for market access. Table 15 presents the road density by region in Mindanao.<sup>6</sup> As could be seen, the region with the longest paved road (concrete and asphalted roads) is Region X with 1451 kilometers. A far second is Region XI with 817 kilometers, followed by Region IX with 659 kilometers and Region XII with 586 kilometers. Region XI ranked first in terms of gravel roads with 13,434 kilometers followed closely by Region X with 12,289 kilometers, then by Region XII and Region IX.

<sup>6</sup>Available data used to estimate the road density in Mindanao follow the previous regional delineation, i.e., without the ARMM.

**Table 15. Road density, by region, Mindanao, as of 31 December 1990  
(kilometers)**

Region	Area (sq. km.)	Paved (km)	Gravel (km)	Total (km)
IX	18,685.14	659	9646	10305
X	28,327.74	1461	12289	13750
XI	31,692.75	817	13434	14251
XII	23,293.23	586	9812	10398
Mindanao	101,998.86	3523	45181	48704
*** meters per square kilometer **				
IX		35.27	516.2	551.5
X		51.57	433.8	485.4
XI		25.78	423.8	449.6
XII		34.54	442.9	477.5

Sources: Department of Public Works and Highways,  
Department of Environment and Natural Resources.

It is observed that road density in Mindanao is well below what planners would generally consider as optimum access to market. Thus, on the average, there are only 34.54 meters of paved road per square kilometer of land in Mindanao. Including gravel road, the road density in Mindanao rose to 477.5 meters per square kilometer of land. The highest road density of paved roads is in Region X followed by Region IX. Inclusion of gravel roads to paved roads gave Region IX the highest road density of 551.5 meters per square kilometer followed by Region X with 485.4 meters of roads per square kilometer of land. The low road density in Mindanao particularly the paved variety may have a negative impact on the marketing of agricultural products. This negative impact could be seen in the market spread and the high incidence of post-harvest losses. Empirical data to directly support the aforementioned hypothesis are not available to this paper, nevertheless, the common complaint that the dealers and the traders exploit the farmers is, by and large, a result of the risks factor component that produces a large markup on inputs and markdown on farm produce under an inadequate transport infrastructure.

### 2.5.2 Irrigation systems

The development of irrigation systems in Mindanao introduces control on water availability and access, hence lesser dependency on the weather. Irrigation systems also counteract the seasonality of agricultural production and therefore help stabilize agricultural production throughout the year. There are three types of irrigation systems in Mindanao in terms of ownership, namely, national, communal,

and private. Table 16 presents the potential irrigable area and service area of existing irrigation systems in Mindanao by region.

The assessment of the National Irrigation Administration in December 1994 reveals that Mindanao has a potential irrigable area of 959,001 hectares or about 31 percent of the total potential irrigable area of the country. For the whole of Mindanao, only about 27 percent of the total potential irrigable area is covered by three irrigation systems (national, communal, and private) as of December 1994. This leaves about 73 percent of the total potential irrigable area available for future expansion. By type of system, the national irrigation systems account for about 54 percent of the total irrigated area in Mindanao. This is followed by the communal systems with 39 percent and the private irrigation systems with 7 percent.

Region-wise, Southern Mindanao has the largest irrigated area with 85,145 hectares followed by Central Mindanao with 83,550 hectares. Northern Mindanao has 58,010 hectares under irrigation while Western Mindanao has an irrigated area of 31,347 hectares. Central Mindanao's irrigated area is only 23 percent of its potential irrigable area and therefore among the regions of Mindanao has the greatest area for irrigation expansion. The other two regions with sizeable area for future

**Table 16. Potential irrigable area and existing irrigated area, by region, Mindanao, December 1994 (in hectares)**

Region	Estimated Potential Irrigable Area	National	Communal	Private	Total	Percent of Potential Irrigable Area
Western Mindanao	76498	14282	15213	1852	31347	40.98
Northern Mindanao	230148	29540	25813	2657	58010	25.21
Southern Mindanao	290278	46988	27631	10531	85145	29.33
Central Mindanao	362077	47399	32420	3731	83550	23.08
Mindanao	95901	138204	101077	18771	258052	26.91
Philippines	3126297	651812	442006	174610	1268428	40.57
Percent of Philippines	30.67	21.20	22.87	10.75	20.34	

Source: National Irrigation Administration.

irrigation expansion. The other two regions with sizeable area for future irrigation expansion are Northern Mindanao whose 75 percent of its potential irrigable area is not yet covered by the present irrigation systems, and Southern Mindanao with 71 percent of its potential irrigable area still untapped. Western Mindanao has the lowest potential irrigable area in Mindanao of 76,498 hectares. About 41 percent of that potential irrigable area is presently served by irrigation systems.

Full utilization of the potential irrigable areas of Mindanao clearly depends on whether the watershed areas of Mindanao could be regenerated and maintained. Accordingly, the utilization of those potential irrigable areas would depend on the reforestation programs of the government. Likewise, soil conservation will have a significant role to play. The magnitude of soil erosion in Mindanao necessarily implies that most of the rivers and streams of Mindanao are now heavily silted. This condition affects the efficiency of irrigation systems.

### **3. A CONCEPTUAL FRAMEWORK ON THE USE OF NATURAL RESOURCES AND ENVIRONMENT**

Until recently, the apparent framework used in the utilization of natural resources appeared to be that of a resource that is inexhaustible. Accordingly, trees of the Mindanao forests were felled with abandon. Land, especially in the 1950s, was abundant and indeed was usually given almost free to settlers. The same is true with the fishery resource. Fishes were caught usually by dynamite and by poison. Sustainable development only came after symptoms of impending environmental disaster started to appear on the horizon.

In Mindanao, a more serious examination on the role of land, natural resources, and environment in development is fairly recent. Although the idea that these resources are not inexhaustible nor free are treated in national development plans, in regional development plans, and in several statutes of the country, implementation of these plans and enforcement of these statutes are, by and large, half-hearted and in some cases the opposite appeared to be promoted. Accordingly, necessary conservation measures and regeneration of these resources to insure their optimum utilization and sustainability are less than satisfactory. A number of factors may be cited to have contributed to the malaise. Among these factors are: (a) the absence of a long range strategic planning on the role and utilization of land, natural resources, and environment in the over all development of the island, (b) the very short term perspective of the people on resource use, (c) the absence of enforcement of policies to regenerate the resources by the companies given the concessions to exploit them, and (d) the exploitation of these resources basically carried out to finance consumption and practically little used for investment especially in Mindanao. Obviously, there are other factors that are equally important, but the convergence of these factors plus the rapidly increasing population combined to produce a significant degradation of natural resources in Mindanao.

Theoretically, a model of resource utilization may be constructed simply as one which guarantees optimum extraction under the condition that what is ex-

tracted is equally replenished. Applied particularly to biological resources, e.g., fishery and forestry, the model requires that the maximum level of resources use or extraction is known under a given state of technology. This model may be presented as follows:

Let:

- $K$  = the maximum level of extraction or utilization compatible for the stock of resource to replenish itself.  
 $r$  = the rate of extraction  
 $Y$  = the amount of resource extracted at year  $t$   
 $t$  = time in years

Then, the intertemporal extraction path may be represented by a logistic function of the form:

(1)

$$Y = \frac{K}{1 + e^{rt}}$$

where:  $r = a - bt$

The growth path defined by Equation 1 is for the curve to increase then become asymptotic to  $K$  starting at a certain time  $t$ . For the above situation to happen, the exponent of  $e$  should be in the form of  $(a - bt)$ . Graphically, the resource use defined by this model may be presented as in Figure 1.\*

It should be noted that  $K$  may shift upward or downward depending upon the technology used for the resource to replenish itself. Such technology necessarily needs institutional support to insure that the resource replenishment process will not be short circuited. Note that a situation may also occur wherein resource exploitation does not have any provision for resource regeneration or there is a neglect in resource replenishment. In this situation, the logistic curve will take the opposite form of Figure 1, i.e., it will become asymptotic to the X-axis or a resource level near the X-axis (see Figure 2).

Taking a particular resource, say forestry as an example, then Figure 2\* may be interpreted as follows: Resource exploitation is massive during the early years with or without minimal resource regeneration. Consequently, the stock of forest products continually declines. Logs harvested may indicate very high volume during the early years, but will later rapidly decline. It is believed that the exploitation of forest resources of Mindanao and, in some instances, the fishery resources took the form of Figure 2. Basically, this is because during the early part of forest resource exploitation trees were cut and mountains made bare without significant efforts to replace those trees felled. The same may be said of fishery resources with the wanton destruction of coral reefs, mangroves, and use of dynamite and poison in catching fish.

\* Figures 1 to 11 were not submitted by the author in time for publication.

Application of the model to a specific resource is straightforward. On fisheries,  $K$  or the upper limit of the logistic curve is the maximum sustainable yield (MSY) of a given fishing ground, say Davao Gulf. The application of the model to forestry is basically the same. The upper limit  $K$  is defined by the maximum allowable harvest for a given forest area. Note that the model uses the maximum allowable harvest as the amount or volume of logs that could be cut annually as equal to the volume of logs that could be replenished annually.

Equation 1 presents a simple model of resource exploitation. A more sophisticated theoretical framework for analyzing the use or exploitation of land, natural resources, and environment is through the use of a natural resource accounting model.<sup>7</sup> The basic idea of this model is that land, natural resources, and environment depreciate or are affected by activities of men. For example, soil loses its fertility because of soil erosion, the amount of mineral deposits decrease by mining or mineral extraction, the quality of air is diminished by pollution, etc. Accordingly, the reduction of the quality or amount of resources impact upon the productive capacity of the resources. The economy's balance sheet which provides a picture of the financial or wealth position of the economy is made to reflect the depreciation of natural resources. Correspondingly, a reduction of soil fertility lowers productivity, hence affects the economy's total output. A similar argument may be advanced for changes in environmental quality. It should be noted that the present national accounting system used by the Philippines, hence, also of Mindanao, does not include natural resource accounting, or to be specific, does not consider depreciation of natural resources in the estimation of the gross domestic product (GDP). Accordingly, the present GDP of the country and of Mindanao may be underestimated or overestimated depending upon the movement of the stock of natural resources in Mindanao or in the country.

The national resource accounting model may be illustrated by the following accounting equations for forest and petroleum resources.

### 3.1 Forestry and Mineral Resources Accounts

Using a suitable physical unit to measure the volume of economically extractable logs or forest products and defining the following variables as:

$$\begin{aligned} X_{os} &= \text{the opening stock of forest at the start of the year } t \\ X_g &= \text{the addition of forest through growth at year } t \end{aligned}$$

<sup>7</sup>See: Y.J. Ahmad, S. El Serafy and E. Lutz, *Environmental Accounting for Sustainable Development*, The World Bank, Washington, D.C., 1989; R. Repetto, W. Magrath, M. Wells, C. Beer, and F. Rossini, *Wanting Assets: Natural Resource in National Income Accounts*, World Resources Institute, Washington, D.C., 1989; United Nations, *Provisional International Guidelines on the National and Sectoral Balance-Sheet and Reconciliation Accounts of the System of National Accounts*, Statistical Papers, Series M, No. 60, Department of Social Affairs, New York, 1977; and United Nations, *Future Directions of Work on the System of National Accounts*, Economic and Social Council, Statistical Commission, New York, 1980.

$X_r$	=	the addition of forest through reforestation at year $t$
$X_h$	=	the reduction of forest by harvesting at year $t$
$X_d$	=	the reduction of forest by deforestation at year $t$
$X_{ld}$	=	the reduction of forest by logging damage at year $t$
$X_{fd}$	=	the reduction of forest by fire damage at year $t$
$X_{cs}$	=	the closing stock of forest at the end of the year $t$
$X_{nc}$	=	the net change of forest stock at year $t$

Then, the accounting equation for the stock of economically extractable forest products may be expressed as:

$$(2) \quad X_{os} + X_g + X_r - X_h - X_d - X_{ld} - X_{fd} = X_{cs} \quad \text{and}$$

$$(3) \quad X_{nc} = X_{os} - X_{cs}$$

Alternatively, a similar accounting equation may be used for mineral resources. Thus, using a different notation, let:

$Z_{os}$	=	opening stock of economically extractable mineral(s) at time $t$
$Z_d$	=	new discoveries of economically extractible mineral(s) at time $t$
$Z_{dp}$	=	depletion of mineral stock at time $t$
$Z_{cs}$	=	closing stock of mineral deposit at time $t$
$Z_{nc}$	=	net change of mineral(s) stock at time $t$

The accounting equation for mineral stock is:

$$(4) \quad Z_{os} + Z_d - Z_{dp} = Z_{cs} \quad \text{and}$$

$$(5) \quad Z_{nc} = Z_{os} - Z_{cs}$$

Accounting equations for land and environment may be constructed<sup>8</sup> to determine the status of these resources through time. On the other hand, providing a system of valuation to the accounting formulas converts them into their monetary equivalent.

### 3.2 Food Security

A number of models may be used to evaluate the food security of Mindanao. The simplest perhaps of these models is one that could assess the capacity of Mindanao to feed its growing population. Using rice as the focus of food security, this simple model is basically a supply and demand model where trade is not

<sup>8</sup>For an example of an accounting equation for the environment see: D.W. Pearce and A. Markandya, "Marginal Opportunity Cost as a Planning Concept in Natural Resource Accounting" in G. Schramm and J.J. Warford, (eds.), *Environmental Management and Economic Development*, A World Bank Publication, The Johns Hopkins University Press, Baltimore, 1989.



included. In effect, supply is equal to domestic production which in turn is equal to the area harvested multiplied by yield per hectare. Demand may take two forms, namely, an income and price neutral demand, and a demand affected by changes in income and prices. The former is simpler since aggregate demand in this case is basically per capita consumption multiplied by the total population. Consequently, it is only necessary to project population to determine the future demand for rice. The latter necessitates the determination of income and price elasticities of demand and a projection of income and price growth rates if the object is to project the future demand for rice.

These models could obviously provide policy makers with valuable information on the capacity of Mindanao to meet the food requirement of its growing population, and on the stock of resources, as well as the relative rate of their depletion. In addition, the inclusion of the natural resources accounting into the conventional economic accounting system, i.e., the determination of the gross domestic product provides policy makers with very valuable information on the use of income derived from natural resources. This information will enable policy makers to adjust the rate of extraction of natural resources so as to enable that resource to replenish itself, i.e., if the resource is renewable or biological in nature. It is noted, however, that these models, particularly those on natural resources accounting require a sizeable amount of data, and these data should be reliable to be of help to decision makers.

For policy makers of Mindanao, the use of these models will be of great interest to the area's economy. First, assuming that the maximum sustainable yields of the different fishing grounds of Mindanao are known, then policies to avoid overfishing could be instituted and adequate resource conservation and regeneration measures could be implemented. The same is true with the forest resource. A natural resources accounting system in Mindanao, on the other hand, not only could provide more detailed information on the state and the rate of natural resources depletion of Mindanao, but could also enable policy makers to determine how the income from natural resources is used. A simple model on food security, on the other hand, could provide policy makers with an idea of the level of population that Mindanao could support.

Application of Equation I to forestry and fisheries sectors of Mindanao is straightforward if, for example, in the case of fisheries as MSY for a certain species or certain group of fishes is known. The same could also be said of the forestry sector. On the other hand, the application of the accounting formula will be difficult if there are no available and reliable data on the stock, the rate of annual extraction, and replenishment or new resource discoveries.

#### **4. SCENARIOS ON THE USE OF LAND, NATURAL, AND ENVIRONMENTAL RESOURCES OF MINDANAO**

This section will essentially focus on the capacity of Mindanao to feed its growing population. Although after the discussion on land and food security in

Mindanao, a discussion on the implication of the available time series data on forestry and fisheries will be also presented. Basically, this is because in the case of forestry, the most critical program at present is to reforest the areas that had been denuded or the areas identified to be developed as forest areas. In the case of fisheries, an intensive program of rehabilitating Mindanao's aquatic and marine resources should be given top priority. In addition, to control fisheries production, the maximum sustainable yield of fishing areas of the island should be known.

#### 4.1 Land Resources and Food Security

This section will define food security in the narrow sense, i.e., the capacity of Mindanao to produce rice to feed its growing population using primarily Mindanao land resources. The following assumptions are also used; (a) rice consumption is not affected by income, hence, aggregate rice demand is equal to per capita consumption multiplied by Mindanao population; (b) the population of Mindanao grows following the medium assumption; (c) milling recovery is equal to 65 percent; and (d) yield of palay per hectare may be based on the yield obtained by experimental stations.

The preceding assumptions obviously will produce a number of plausible scenarios on the capacity of Mindanao to produce enough rice to feed its growing population. This section will consider only two or three of these scenarios. These scenarios will take the form of a particular set of yield per hectare, growth rate of irrigated areas, and cropping index. Mindanao population is assumed to be the same for all scenarios. The Mindanao population for the next 20 years is presented on Table 17. Figures 3 and 4\* present the per capita land availability up to 2015.

##### 4.1.1 *Base scenario*

This scenario assumes that the area planted and yield per hectare of palay for irrigated, rainfed, and upland areas remain the same. It also holds the reported cropping indices for the three crops areas constant. Basically, this scenario therefore produces constant rice production during the entire projection period. Table 18 presents the supply and demand for rice in Mindanao on selected years under this scenario. Figure 5\* presents the yearly projected production and demand for rice under the base scenario. As could be noticed, Mindanao will incur deficit in rice starting 2000 under this scenario.

##### 4.1.2 *Medium intensity palay production scenario*

Under this scenario, the area under irrigation is assumed to expand at the rate of 2.5 percent per annum, while rainfed and upland areas planted to rice will decrease at the rate of -2.5 and -1.5 percent respectively. Yield per hectare of irrigated areas is assumed to increase at the rate of 2.5 percent per annum while that of rainfed areas is assumed to expand at 0.1 percent annually. Cropping indices for irrigated and rainfed areas are held at their present observed values.

**Table 17. Mindanao population, 1996 to 2020  
(in thousands)**

Year	Western Mindanao	Northern Mindanao	Southern Mindanao	Central Mindanao	Mindanao
1996	3603	4167	4952	3378	16100
1997	3671	4260	5055	3452	16438
1998	3739	4354	5158	3527	16778
1999	3806	4447	5261	3601	17115
2000	3874	4540	5364	3675	17453
2001	3941	4632	5465	3750	17788
2002	4006	4724	5565	3823	18118
2003	4071	4815	5665	3985	18446
2004	4134	4904	5762	3967	18767
2005	4196	4993	5859	4037	19085
2006	4256	5079	5952	4106	19393
2007	4315	5164	6044	4174	19697
2008	4370	5247	6133	4240	19990
2009	4477	5405	6304	4368	20554
2010	4477	5405	6304	4368	20554
2011	4528	5482	6387	4430	20827
2012	4580	5560	6470	4495	21105
2013	4631	5638	6555	4558	21382
2014	4684	5715	6641	4623	21663
2015	4735	5793	6728	4690	21946

Source: NSCB, *Philippine Statistical Yearbook*, 1993.

It is clear that increasing the irrigated area annually by 2.5 percent any yield per hectare by also 2.5 percent enables Mindanao to satisfy its rice requirement up to the year 2015. The surplus rice production of Mindanao under this scenario ranges only from 47 to 102 thousand metric tons (Table 19, see also Figure 6\*).

#### 4.1.3 High intensity production scenario

Under this scenario, irrigated area is expected to grow at the rate of 3 percent annually and cropping index for irrigated area is placed at 2.0. All other assumptions under the medium intensity scenario remain the same. Table 20 presents the production and demand for rice under the high intensity scenario.

**Table 18. Projected production and demand for rice under the base scenario, Mindanao, 1997 to 2015**

Item	1997	2000	2005	2010	2015
Irrigated area (ha)	324211	324211	324211	324211	324211
Rainfed areas (ha)	231449	231449	231449	231449	231449
Upland areas (ha)	53281	53281	53281	53281	53281
Total Production (000 mt)	1859.522	1859.522	1859.522	1859.522	1859.522
Total Demand (000 mt)	1738.8	1884.024	2061.18	2219.832	2376.168
Surplus/Deficit ( $\pm$ 000 mt)	120.7226	-25.4013	-201.657	-360.309	-510.645

**Assumptions.**

Yield per hectare, irrigated = 3.42 mt (palay)

Yield per hectare, rainfed = 2.38 mt (palay)

Yield per hectare, upland = 1.45 mt (palay)

Cropping index, irrigated area = 1.79

Cropping index, rainfed area = 1.45

Cropping index, upland area = 1.0

Palay to rice conversion ratio = 0.65

This scenario will obviously entail a greater investment from the government for a sustained irrigation system expansion. Nevertheless, it is the scenario that could comfortably satisfy the food security requirement of Mindanao and at the same time contribute significantly to the buffer stock requirement of the country. Under this scenario, rice surplus of Mindanao will increase from 302 thousand metric tons in 1997 to 579 thousand metric tons in 2015 (see also Figure 7\*).

**4.2 Supply and Demand for Logs**

Mindanao's requirement for logs is estimated from the national wood requirement projections of the Forest Management Bureau. The country's aggregate demand for timber is projected to increase from 2.35 million cubic meters in 1994 to 2.83 million cubic meters in year 2000. Domestic production of timber, on the other hand, is projected to remain constant at 0.796 million cubic meters. The country therefore had a timber deficit of 1.552 million cubic meters in 1994. This deficit is

**Table 19. Projected production and demand for rice under the medium intensity scenario, Mindanao, 1997 to 2015**

Item	1997	2000	2005	2010	2015
Irrigated area (ha)	332326.5357879.3	404907.6	458115.7	518315.9	
Rainfed areas (ha)	225662.7	209157.6	184287.9	162375.2	143068.1
Upland areas (ha)	52481.78	50155.35	46504.87	43120.08	39981.65
Total Production (000 mt)	11911.609	1976.576	2109.105	2273.730	2472.955
Total Demand (000 mt)	1738.8	1864.924	2061.18	2219.832	2378.168
Surplus/Deficit ( $\pm$ 000 mt)	136.3050	91.65283	47.925	53.89863	102.7879

**Assumptions:**

Yield per hectare, irrigated = 3.42 mt (palay)

Yield per hectare, rainfed = 2.38 mt (palay)

Yield per hectare, upland = 1.45 mt (palay)

Growth rate, irrigated yield/ha = 2.5 percent

Growth rate, rainfed yield/ha = 0.1 percent

Growth rate, irrigated area = 2.5 percent

Growth rate, rainfed area = -2.5 percent

Growth rate, upland area = -1.5

Cropping index, irrigated area = 1.79

Cropping index, rainfed area = 1.45

Cropping index, upland area = 1.0

Palay to rice conversion ratio = 0.65

projected to increase to 2.034 million cubic meters of timber by year 2000<sup>9</sup>. Table 21 presents the projected supply and demand for timber in the Philippines and the estimated demand for timber in Mindanao.

Mindanao log production in 1993 was 935 thousand cubic meters. This is greater than the projected supply of timber in 1994. Obviously, Mindanao may be able to satisfy the timber demand of its population for a few more years, but it is doubtful if this could be sustained with the present rate of reforestation.

Exploitation of the forest resources of the Philippines and of Mindanao has taken the form of a logistic function where the asymptote is near the X-axis. Figure

<sup>9</sup>Forest Management Bureau, DENR, as cited by the Philippine Wood Producers Association, "Situationer on Philippine and Wood-based Industry", Makati, Philippines.

**Table 20. Projected production, and demand for rice under the medium intensity scenario, Mindanao, 1997 to 2015**

Item	1997	2000	2005	2010	2015
Irrigated area (ha)	333947.6	364913.5	423034.8	490413.3	568523.4
Rainfed areas (ha)	225662.7	209157.6	184287.9	162375.2	143068.1
Upland areas (ha)	52481.78	50155.35	46504.87	43120.08	39981.65
Production (000 mt)	2078.015	2179.878	2385.462	2640.124	2949.773
Total Demand (000 mt)	1738.8	1884.924	2061.18	2219.632	2378.168
Surplus/Deficit ( $\pm$ 000 mt)	302.7110	294.9545	324.2829	420.2922	579.6057

**Assumptions:****Assumptions:**

Yield per hectare, irrigated = 3.42 mt (palay)

Yield per hectare, rainfed = 2.38 mt (palay)

Yield per hectare, upland = 1.45 mt (palay)

Growth rate, irrigated yield/ha = 2.5 percent

Growth rate, rainfed yield/ha = 0.1 percent

Growth rate, irrigated area = 3.00 percent

Growth rate, rainfed area = -2.5 percent

Growth rate, upland area = -1.5

Cropping index, irrigated area = 2.00

Cropping index, rainfed area = 1.45

Cropping index, upland area = 1.0

Palay to rice conversion ratio = 0.65

8\* presents this mode of exploitation using the national time series data. This mode of exploitation is unfortunately not sustainable. Unless the government could effect a more massive reforestation program, Mindanao will have to import logs to satisfy its domestic demand. Even then, it may take a few decades perhaps to effect a sustainable forest resource level. Figures 9 and 10\* present the trend of exports and imports of logs in the Philippines.

### 4.3 Exploitation of Mineral Resources

Mineral resources are generally non-replenishable. Exploitation of mineral resources therefore needs very close monitoring. This, however, could be done easily if extraction and processing of those ores are organized. If the converse exists, the determination of the output for a particular ore will be difficult. When

**Table 21. Estimated supply and demand for timber, Mindanao and the Philippines, 1994 to 2000**  
(in million cubic meters)

Item	1994	1995	1996	1997	1998	1999	2000
Philippines, projected demand	2.35	2.43	2.5	2.58	2.5	2.74	2.83
Philippines, projected supply	0.786	0.796	0.796	0.796	0.796	0.796	0.796
Surplus/ Deficit	-1.554	-1.634	-1.704	-1.784	-1.704	-1.944	-2.034
Mindanao, projected demand	0.540	0.559	0.576	0.595	0.578	0.635	0.656

Note: Mindanao timber demand is based on national per capita demand.  
Source: DENR, Forest Management Bureau.

this happens, the rate of resource depletion and the efficiency of the method of extraction can only be conjectured. Extraction of gold is perhaps one for which the true production figures given may be different from the published government statistics. First, because the numerous small scale gold miners monitoring is difficult, and second, open borders allow transfer of gold from one place to another with little or no constraint.

The published data for 1990 to 1991 revealed declining gold and other metals production of Mindanao. It is not possible for this paper to find out the reason or reasons for such drop in production or to find out whether the decline in production was continued after 1991. The magnitude of gold output of Mindanao, however, indicates that a large portion of the known gold deposits of Mindanao is still to be tapped. The same is true with the other metallic ore deposits of the island.

#### 4.4 Sustainability of Fish Production

Commercial, municipal, and aquaculture fish production registered annual growth rates ranging from 5 to 9 percent during the period from 1979 to 1986. The trend of fish production under these three fishing categories is shown on Figure 11\*. It is observed that aquaculture showed a very promising trend with production increasing annually at the rate of 9.49 percent and output had more than doubled from 115,748 metric tons in 1979 to 263,662 metric tons in 1988. Commercial

fishing appeared to be levelling off. This however, follows from what is observed by most countries, i.e., fish stocks are rapidly being depleted. Municipal fishing data present a very disturbing picture. Basically, this is because there is a consistent downward trend of municipal fishing output starting from 1983. The data imply that municipal waters are now overfished.

The data presented, however, are not enough to enable policy makers to determine the annual amount of fish that could be harvested from a particular body of Mindanao marine and fresh waters. For this, it is necessary to determine first the maximum sustainable yield of these waters. Sustainability of fishing waters of Mindanao therefore can not be determined at this time. Nevertheless, we can conjecture, based on the data, that municipal fishing has perhaps already passed its sustainability level. Meanwhile, serious attention should now also focus on commercial fishing with its volume of fish catch starting to taper off. Mindanao, however, may give serious attention to aquaculture as a major source of fish in the years to come. Consequently, the technology of aquaculture has to be consolidated and further developed to support this program.

## 5. SUMMARY AND RECOMMENDATIONS

This paper has presented a selective survey of the land, natural resources, and environment of Mindanao. The discussion, although not exhaustive, has presented both the immense potential, as well as the problems confronting Mindanao. Available data reveal a sizeable area for irrigation expansion in Mindanao which translate to a significant agriculture output expansion if investment in irrigation systems is directed to those areas. On the other hand, the data also reveal that a significant amount of damage had already been inflicted on land, forest, and fishery resources of Mindanao. The precise magnitude of the environmental damaged is not yet fully assessed. For example, the statistics on soil erosion certainly have significant bearing on agricultural productivity and on both the fresh and salt water biological resources of Mindanao. Their effects, however, can only be conjectured at present. Similarly, the effect of forest denudation is already felt by the abnormal occurrence of floods and the damage the flood inflicts on lives, crops, and property. The full impact of forest denudation on other components of the ecological system, however, is not yet fully appreciated.

The state of the land, natural resources, and environment in Mindanao is not unknown to development planners. The 1993 to 1998 Regional Development Plan of Southern Mindanao, for example, presented a graphic picture of land, natural resources, and environment in Mindanao. The plan noted that the region's ecological landscape has been considerably altered. The forest resource of the region is at present severely depleted. Consequently, the lakes and rivers of the region are heavily silted causing a steep decline in the productivity of agricultural crops. In addition, the massive deforestation of the region contributed significantly to flash floods in several areas of the region causing damage to property, crops, and lives. Deforestation has also affected the region's 48 watershed areas covering about 38



percent of the region's total land area. It has been reported that those watershed areas are now in critical condition. Unless regenerated, it is projected that such watershed destruction will cause inadequacy of water for domestic, industrial, and agricultural purposes in the near future.<sup>10</sup>

Deforestation is not confined to the mountains. It is also severe in the mangrove areas. It is estimated that the total mangrove area of the region has dropped to 7,697 hectares in 1988 or a decline of about 58 percent from the 1972 figure of 17,388 hectares. The massive destruction of the mangrove areas of the region has effectively compromised the breeding areas of fishes and other marine organisms, as well as enhanced rapid erosion of the shorelines of the region.<sup>10</sup>

Heavy pollution is now also observed in major rivers and bodies of water traversing large agricultural plantations, industrial establishments, and urban areas. Basically, this is because of the heavy use of agricultural chemicals, lack of solid and liquid wastes management, and absence/non-implementation of zoning laws or ordinances.<sup>10</sup>

Based on the state of land and forestry resources of other regions of Mindanao, it is not surprising if conditions or the problems faced by Southern Mindanao are also encountered by other regions. Nevertheless, Mindanao has land resource that can ensure food security of the island's population and add considerably to the country's buffers stock if the potential irrigable areas are used. It is estimated that expansion of irrigable area by 2.5 percent annually for the next twenty years can already insure food security under achievable land productivity. A three percent annual increase of irrigable area will enable Mindanao to contribute significantly to the country's food security.

The current state of the forest in Mindanao is hardly capable to meet the timber demand of its population. It is expected that this situation will persist for many years.<sup>11</sup> Obviously there are limits of reforestation: first, the original biodiversity will be difficult if not impossible to restore; second, it assumes a government that could impose its preference over a long period of time; and third, the intensive and sustainable reforestation program should obviously dovetail with other policies of the government, e.g., population control, industrialization, agriculture development, etc. Reforestation programs, particularly those that are focused on the watershed areas, will assume a critical role in the years to come. Essentially, this is because reforestation of watershed areas will affect to large a extent the sustainability of existing irrigation systems and the utilization of the potential irrigable areas of Mindanao. Second, the reforestation of watershed areas will significantly determine the lifespan and usefulness of hydroelectric dams, and third, the demand for water

<sup>10</sup>Regional Development Council, *Southern Mindanao Region Development Plan, 1993-1998*. Davao City, Philippines, 1993, Chapter 2.

<sup>11</sup>At a Senior Educators' Conference on Environmental Planning and Management, 29 to 30 May 1996, a senior official of DENR said restoring Philippine forests may take 100 years.

for both domestic, as well as industrial uses will have a greater probability of being satisfied if the watersheds of these water sources could be regenerated and conserved. Note that the preceding role of reforestation impacts on food security, energy, and domestic and industrial water supply of Mindanao.

The fishery sector occupies a strategic position in the economy of Mindanao, first, as an important source of protein, second, as an important source of income, and third as an important export commodity. The fisheries resources of Mindanao, are nearing their critical level, if this is not reached yet. Definitely, major portions of the municipal fishing areas are already at their critical stock level. Replenishing the municipal fishing areas needs a multipronged approach. This will include, among others, (a) regeneration and conservation of mangrove areas, (b) regeneration and conservation of corals, (c) delineating fish sanctuary areas, (d) breeding of fishes and releasing them at the municipal fishing areas, (e) education and training of municipal fishermen on sustainable fishing practices, and (f) transfer of a portion of municipal fishermen to other occupations. Commercial fishing is also nearing its critical level. It is important that policies to control this type of fishing be formulated, particularly within the Philippine Economic Exclusion Zone (EEZ). These policies should consider the type of fishing gears to use and the volume of allowable fish catch annually. Aquaculture holds great potential for the Mindanao fishery sector. Lakes, rivers, and bays/gulfs of Mindanao have yet to be utilized for fish farming. As opposed to the natural propagation of fish, fish farming or its variants, multiplies the capacity of the fishery sector to produce fish in both fresh and salt water. The technology of aquaculture, however, needs to be transferred to the production level to avoid overloading water bodies of their capacity to support production activities. The problem of overloading, among others, appears to be getting serious in some areas of the country. Aquaculture requires a strict maintenance of good water quality. Water pollution as cited in the Southern Mindanao Region Development plan for 1993 – 1998 will not be compatible with aquaculture.

The long term economic development of Mindanao, although demanding significant contributions from its land, forest, and fishery resources, may have to look into the mineral resources of the island as a source of economic growth. Unfortunately, the exploitation of both metallic and non-metallic resources leaves a lot to be desired both in the utilization of its backward and forward linkages and by the manner of its exploitation. Region XI, for example, produces a sizeable amount of gold through small scale mining. This gold, however is immediately exported outside Mindanao and no effects at present have been done to promote the lucrative jewelry subsector. Meanwhile, with total disregard for environmental hazards, processing of gold using mercury and cyanide poisons the rivers, the seas, and the environment of parts of Region XI. Non-metallic resources of Mindanao, for example, clay and others, could serve as raw materials for the development of high technology industries of Mindanao, like electronics, computer parts, electrical appliances and parts, machine fabrication, and the like.

Available data on soil erosion, volume of existing forest, trend of fish catch, and the mode of exploitation of minerals of Mindanao reveal a system that needs redirection in the years to come. Specifically, a set of policies have to be formulated to ease the pressure on land and natural resources of Mindanao. These policies should cover land conservation and cultural practices, reforestation and forest conservation, and regeneration of Mindanao fishing waters. A serious look should also be given to solutions outside land and natural resources sectors. These are: (a) the industrial/manufacturing sector and (b) the demographic sector. The industrial/manufacturing sector could provide employment and higher income although it may require complementary policies from the education sector with regards to the training or skills acquisition of workers. Population control is a controversial issue in the Philippines and in Mindanao. Nevertheless, it cannot be denied that the degradation of land, forest resources, and fishery resources are directly related to population pressure. Consequently, before it becomes very, very late, the country has to make a firm decision on the population issue.

## Panelists

**ANACLETO M. PEDROSA, JR., Ph.D.**

*Executive Director*

*Regional Council for Research and Development  
(RECORD) Foundation, Inc.*

The paper of Dr. Prantilla discussed thoroughly the subject on land, resources, and environment of Mindanao and their uses for development. His land use suggestion as a development planner and economist fitted very well in many cases of agricultural land use and location of agroindustrial centers in many areas of Mindanao. For example: the estimated 50 thousand hectares or so of pineapple found in Mindanao are found in the warm-cool uplands of Bukidnon, Davao, and South Cotabato at an elevation of 200-400 meters. The 2000 hectares of tomatoes targeted to supply the need of the tomato paste plant at Manolo Fortich in Bukidnon are found in higher elevations (400-500 meters) in Claveria, Sankanan, Kisolon, and Valencia, Bukidnon. The cool highlands (500 meters and above) are the targeted areas for leafy vegetables and potatoes. Such areas are located in Lantapan, Bukidnon; the Davao-Cotabato ranges; Maragusan, Davao del Norte; Kapatagan, Davao del Sur; Makilala, Kisante, Bulatukan of North Cotabato; and Miason, Tupi, Polomolok, and T'boli highlands of South Cotabato. The 40 thousand hectares of exported Cavendish bananas are grown in the warm lowlands where the sugar cane, solo papaya, and asparagus, are also grown. Coconuts, rice, corn, cotton, other native bananas, and mango are also grown in the warm lowland areas. As cited, these are also the areas with dense population, centers of non-agricultural activities, and rapid urbanization. There are also increasing cases of shifting from the traditional crops i.e., coconut, coffee, including rice and corn, to high value, export-oriented crops like banana, pineapple, papaya, asparagus, and mango. Population pressure and industrialization are likewise exerting a heavy toll on these prime agricultural areas.

While it was cited in the paper that 50% of the 10.2 million hectares in Mindanao are in various degrees of soil erosion, the 60 years of pineapple culture and cultivation in Bukidnon, and 25 years in South Cotabato have not been correlated with increased siltation and soil erosion in those areas. This shows that erosion control can be attained through careful engineering plans and contour farming, in spite of large tracts of sloping land.

Forest denudation and swidden cultivation are accepted facts in Mindanao which contribute heavily to soil erosion in steep slopes and cool hilly lands. Initial attempts to reforest these areas through government issued reforestation contracts have failed miserably. The reported 1,375 thousand hectares that were reforested in 1993, are not existing anymore. Aerial observation of most new forest covers indicate that these are self-regenerating residual forests. The reforestation project areas were mostly overrun by brushfires, or the planted trees were overtaken by weed growth due to lack of maintenance. The implementation of a community based reforestation program would offer a higher potential for success. Again, granting that successful reforestation activities had been in place, it would take at least 15 years of growth and a whole mountain range cover to obtain the expected impact of flood control and a much longer period to stop soil erosion. What should be done during such a period of vulnerability? The local government units in the affected areas, at the barangay level, should allocate time, money, and pooled labor (through bayanihan) to construct impounding reservoirs in strategic locations (a) to slow down the flow of water, (b) to collect the silt carried by the water, (c) to conserve and store water for community use, and (d) for development as community fish culture projects. Water quality downstream will definitely improve with the number of impounding reservoirs and underground aquifers will be revived by the percolating water from these reserves. In the end, siltation in the shorelines will be minimized.

The effects of the Comprehensive Agrarian Reform Program of the government on land use and global competitiveness of the agricultural sector have not been touched in the paper presented. While novel and innovative systems have been painstakingly installed in some corporate plantations by the organization of Agrarian Reform Beneficiaries Cooperatives, the independent ARBC's which are recipients of CLOA's have not been organized. In addition, large plantations that do not have organized beneficiaries upon implementation of the law in 1997 will probably resort to individual contract growing agreements with each beneficiary. Because of the number of individuals to be managed, this will be a nightmare for the plantation management.

The recommendations proposed by Dr. Prantilla are straightforward and far-reaching. The question as to who should implement these recommendations and how they should be implemented is clearly resting on the shoulders of every citizen of Mindanao. The collective effort of these people could be reflected in the local government plans with all the power that comes with the devolution of authorities to the local government units.

**ALI G. MACAWARIS, Ph.D.**

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First of all, I commend Dr. Edmundo B. Prantilla for presenting a very informative paper on the utilization of land, natural resources, and environment for the development of Mindanao.

The paper dissects the current states and uses of the land, forestry, mineral, and fishery resources and analyzes the status of road network and irrigation systems in Mindanao. It also presents logistical and accounting equations used in the inventory and utilization of forest and mineral resources. Finally, it discusses food security, supply and demand for timber, exploitation of mineral resources, and sustainability of fish production.

Dr. Prantilla concluded that (a) the present condition of the forests in Mindanao is hardly capable to meet the timber demand of its population, (b) the fishery resources of Mindanao are nearing their critical levels, and (c) economic development of Mindanao demands significant contribution from its land, forest, mineral, and fishery resources.

**COMMENTS ON THE PAPER****Land Degradation Due to Soil Erosion**

Soil erosion is the most critical form of land degradation. The extent of soil erosion is shown in Table 5. Discussion about land degradation with respect to the economic growth of Mindanao is not complete without including coastal erosion because eco-tourism is one of the components with development in the Brunei, Indonesia, Malaysia, and the Philippines-East Asia Growth Area (BIMP-EAGA).

The effort to develop coastal and island resorts in the country is hampered by receding coastlines. Some coastal areas in Mindanao, especially those exposed to the Pacific Ocean, Celebes Sea, and South China Sea are subjected to severe scouring. In several cases, the rate of erosion is more than 1.5 meters per year.

It is recommended that coastal erosion be included in the discussion of land degradation.

**Logistical Function Used in Resource Utilization**

The logistical function used in resource utilization is expressed below.

$$Y = \frac{K}{1 + e^{-rt}} \quad \text{Equation (1)}$$

where

$$r = a - bt$$

The variables  $K$ ,  $Y$ ,  $r$ , and  $t$  are defined as shown on page 70 of the paper of Dr. Prantilla.

One of the purposes of the paper is for a reader to use the equation. It is difficult to utilize it because the constants "a," "b," and "e" are not defined. This leaves a wide area of conjecture with respect to their values.

It is suggested that the constants be defined in order to correctly use Equation 1.

### Accounting Equations Used in the Inventory of Forestry and Mineral Resources

Accounting equations for the stock of economically extractable forest products and mineral resources are expressed by Equations 2 and 3 on page 72 of Dr. Prantilla's paper. Their application is a straightforward inventory of the net change of forest stock at year  $t$ . They do not, however, indicate the limit of economically exploitable forest products that satisfy the requirements of sustainable development. The limit of the volume of usable resource is usually established by international conventions.

It is proposed that a third equation be included in Equations 2 and 3. It expresses the limit in the form of a constraint as shown below.

$$X_{xc} \leq X_s \quad \text{Equation (3a)}$$

where:

$$\begin{aligned} X_{xc} &= \text{the net change of forest sock at year } t; \text{ and} \\ X_s &= \text{the limit of forest stock that can be extracted at year } t. \end{aligned}$$

### Food Security

The section on food security (Section 4.1, pages 74-80) shows a straight projection of rice production and demand from 1988 to 2015. The forecast is based on the area of land available for rice production, productivity per hectare, and size of population. It presents several scenarios of rice production and demand by assuming several values of area available for rice production, yield per hectare, and population. It concluded that the high intensity scenario is more plausible for Mindanao.

It is noted that the prognosis did not consider the effect of trade and influences of BIMP-EAGA. The rice forecast becomes more realistic if they are taken into account. The rapid industrialization in the South Cotabato-Sarangani-General Santos area and Cagayan de Oro-Iligan corridor encourages the people in Luzon and Visayas to emigrate to Mindanao. This alters the population projection on which the high intensity scenario was based.

By the year 2000, it is expected that the tariff barriers among member-states of BIMP-EAGA will be reduced to minimum. It is possible that Mindanao may be flooded with rice from Sabah in Malaysia and Kalimantan Provinces in Indonesia because its price is usually cheaper than that of local rice. When the Philippine rice was being sold at about P800 per cavan in 1994, the people in Tawi-Tawi were buying Malaysian rice at about P700 per cavan. The importation of foreign rice changes the predicted demand for local rice.

Another aspect of strategic development which has to be included in the food security model is the policy to plant high-value crops and vegetables, such as asparagus. This will reduce the area of the land intended for rice production.

It is recommended that the food security model take into consideration the trade and other effects of BIMP-EAGA to make it attuned to prevailing conditions in Mindanao.

## **RESOURCES THAT ARE NOT COVERED BY THE PAPER BUT WHICH ARE VITAL IN THE DEVELOPMENT IN MINDANAO**

### **Freshwater Resources**

One of the important resources which plays a critical role in the development of Mindanao but not included in the paper is freshwater resources, namely, lakes and rivers. Mindanao has big bodies of water, such as Lake Lanao, Lake Mainit, Lake Sebu, Lake Buluan, and Liguasan Marsh. They are sources of freshwater fish that augment commercial and municipal aquaculture fish yields.

Aside from freshwater fisheries, some of them are sources of hydropower. Lake Lanao, for example, plays a very important role in industrialization because it will be able to supply 70% of the power needs of Mindanao by 2000. It can generate more than 800 megawatts of hydropower, the cheapest form of energy. One of the basic requirements to make a product competitive is to use hydropower, thus lowering its production cost.

### **Cold Deep Seawater Resource**

Cold deep seawater resource is located east, south, and west of Mindanao Island. It has many economic uses. It can be utilized for aquaculture and industrial purposes. An example of the latter is to centrally air condition huge business establishments.

### **Air Conditioning**

Large office buildings, hospitals, supermarkets, and hotels are presently cooled internally and centrally by refrigeration units which require electricity to operate. It is now technically and economically feasible to use cold deep seawater to cool them. Leraand and Ryzin (1966) show in their paper entitled, "Air conditioning with Deep Seawater: A Cost Effective Alternative for West Beach, Oahu, Hawaii", that cold deep seawater as cooler could save up to 80% energy used by conventional chillers.



A cold deep seawater cooling system consists of a seawater supply system, a heat exchanger, and a chilled freshwater loop. The seawater supply system transports cold deep seawater to the heat exchanger to maintain the temperature at the chilled loop by passing the fresh water through a counter-flow heat exchanger. The chilled freshwater and seawater do not mix but, on either side of the plates of the heat exchanger, transfer heat from one fluid to the other. The chilled water is not cooled by a conventional chiller. Finally, the seawater is returned to the ocean through a discharge pipeline after passing the heat exchanger.

### **Aquaculture Uses**

The warm surface seawater and cold deep seawater can be mixed to produce a biologically clean and nutrient-rich effluent. It has a wide range of temperature from 6°C to 25°C. It can be used to help solve problems of high cost of fish feeds and contamination of the fish habitats with diseases, parasites, and pollutants.

Some of its existing aquaculture uses are production of fish, prawn culture, milk fish culture, and seaweed farming. It can also be utilized to rear cold-water fish in the tropics. The resource can undoubtedly increase the fishery yield and export.

### **CONCLUSION**

It is concluded that the content of the paper deviates from its title. It focuses on the current status of potentials of land, mineral, forestry, and fishery resources but overlooks the importance of freshwater and cold deep seawater resources. It did not show a relationship between these potentials and the economic development of Mindanao in the light of the establishment of BIMP-EAGA.

**MELITO S. SALAZAR, JR., Ph.D.**

*Undersecretary, Department of Trade and Industry*

Let me congratulate Dr. E.B. Prantilla for a well-researched paper and for the insightful recommendations. My own reactions to the paper are based not only on our experiences in the Department of Trade and Industry as our department has assisted in facilitating the sustainable development of Mindanao through responsible trade, investment, and industrial activities, but also on my own observations in my various visits to many parts of Mindanao – Tawi-Tawi, Digos, Marawi, Basilan, Cagayan de Oro, etc.

First, it is imperative that development of Mindanao should be directed to the improved quality of life of people in Mindanao, not to the enrichment of a few, who in the area of environment are first to decry the disturbance of the pristine countryside but are blind to the poverty that degrades not only the environment but the dignity and humanity of the people. To this end, a prime objective of sustainable development is the creation of jobs for the many who up to now eke a livelihood

from marginal activities. Thus the focus of the national government efforts, and increasingly also that of local governments, is to attract investments and industries and to promote higher levels of domestic and export trade.

One criticism of greater economic activities is the perceived environmental degradation that industries bring to an area. In fact, when one asks a Filipino on the street, what causes the pollution, more often the reply would be business and industry. Yet the statistics would show that business and industry contribute only 15-20 percent of the pollution but domestic wastes account for the major portion.

It would seem essential for us to educate our people about this situation so that they will practice environmentally sound domestic practices and strongly lobby the local government for better communal sewerage systems and garbage disposal awareness. Blaming others for what we ourselves are responsible will not solve the problem.

The perception of industry as the major culprit also comes from the experiences of the past where loggers ravaged the forests and industries, like cement and chemical plants, polluted the air and the rivers. Today, however, the situation is different. The companies and projects registered by the Board of Investments are required to get a certificate of environmental compliance from DENR. On the other hand, the capital equipment being brought in are manufactured in countries where the environmental or green movement has taken deep roots and thus these equipment are environmentally friendly. That is why the sensational cases in pollution involve not new companies or those set up 3 to 5 years ago but those that have been around in the last decades. The DTI-BOI commitment to sustainable development is borne not only by our membership in the Philippine Council for Sustainable Development but also in our creation of an Environmental Unit last year. We would urge local government units in Mindanao to do likewise.

Second, as the paper reviews the land, mineral, forestry, and fishing resources of Mindanao, we accept the reality that where resources become scarce, there exists a motivation to innovate – by discovering substitutes or to renew by finding new arrangements.

Take the case of forestry resources. There are now increasing investments in industrial tree plantations which have resulted in replanting of thousands of hectares of land. Investors in trade-based industries source raw materials from abroad for reproducing here and developing creative products from wood wastes. The housing needs of the country, even of Mindanao, need not be addressed by timber alone. Many substitutes, not just cement, are available. In Ozamiz City, I visited a rice strawboard plant using British technology while in General Santos I saw a grass-cement board plant. Of course, we have registered three gypsum board manufacturers. The point to stress is that our way of preserving the environment, specifically our forests, is to motivate investments in substitutes and reasonable activities.

In mining, our concern should be both on small-scale and large-scale mining. Experience would show that small-scale mining operators with their “quick return” mentality may be more inclined to adopt less environmentally sound policies

compared to large-scale companies, whose massive investments can be threatened and even lost once closed for environmental reasons. I also am aware that a number of new mining exploration projects are partly financed by international agencies which include adherence to sound environmental practices as conditions to the loan.

In fishing, the use of dynamite and cyanide is also more prevalent in municipal and coastal policy than in deep sea fishing. Greater effort should also be devoted to fish culture; many lakes in Mindanao, especially those under the National Power Corporation, are left untapped.

In land, I agree that a proper land use policy is required. But this will not only come from a thorough analysis of the soil conditions, climatic circumstances, and potential markets which could determine what crops to plant in many parts of Mindanao. In this respect, we also suggest the use of a "nucleus estate concept" where farm units are linked with a processing unit. This processing unit not only commits to buy all the produce but also provide technical and support services to the farmers. This management will improve the efficiency of the processing industry and lessen, if not eliminate, the wastage in the agriculture sector, which has been a perennial problem.

I could go on and on, illustrating how, through innovative investments, we can use Mindanao's land resources and environment for sustainable development. However, I have talked too long and the tasks ahead are so urgent that the talking should stop and the working begin. But it should start with the people who are both the object and agents of sustainable development.



**PLENARY SESSION IV**  
**“THE ROLE OF SCIENCE AND TECHNOLOGY IN**  
**THE DEVELOPMENT OF MINDANAO”**

**The Role of Science and Technology in the**  
**Development of Mindanao**

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and

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**ABSTRACT**

Mindanao, also called the 'land of promise' is populated by about 15 million people composed of 81 percent Christians, 18 percent Muslims and 13 tribal groups. The paper discusses major plans for the development of this land of promise that is rich in natural resources, large arable tracts of land, and well-educated people. New initiatives brought about by the formation of the BIMP-EAGA and the recently approved designation of Zamboanga City as a Free Port Economic Zone, have brought about new directions for the full and maximum development of the agricultural, financial, and investment sectors in the area. Mindanao has been seen as the country's front door to East Asia and a major player in achieving the government's goal of industrialization by the year 2000. The role of science and technology in the planning and implementation of priority leading edge technologies for Mindanao is discussed. Essentially, two major strategies are envisioned. First, is to institute a vigorous and comprehensive transfer of science and technology and commercialization programs for the sectors chosen as priority projects. The second, is to plan for the ultimate development and training for highly competent skilled and unskilled labor force.

## INTRODUCTION

Science and technology are powerful forces in society. Properly planned and executed, the widespread utilization of science and technology can bring about improved socio-economic development. The application and outgrowth of scientific and technological innovations can expand national wealth and individual opportunity, can eliminate spatial and temporal barriers to action, and can contribute to the skills and capabilities of a nation's population.

The administration has set the year 2000 when the Philippines shall attain the status of a newly industrializing country (NIC). In the experience of South Korea, Taiwan, Hong Kong, and Singapore, this state is generally characterized by rapid economic growth. Development in the early 1950s and 1960s has been equated with economic growth, putting a premium on a nation's high level of growth as indicated by its gross national product and per capita income. In the present economic social order, development has been equated with a growing economy paralleled by a reduction or elimination of poverty, inequality, and unemployment. An American economist, Michael Todaro, defines development as "*the process of improving the quality of human lives*". As the new economic tigers in Asia and the world, Singapore, Korea, and Taiwan have joined the ranks of 'developed nations' and entered the international community with high and sustained economic growth. The application of science and technology that supplied the inventions and innovations in these countries has been the most strategic factor that propelled their take-off to industrialization.

The urgency of applying the fruits of science and technology development to national interest need not be underscored. In the Philippines, no less than two Presidents – President Corazon C. Aquino and President Fidel V. Ramos – have put into place incentives and structures that have profound implications in the rapid development of science and technology. On his first official visit to Mindanao in August 1992, President Fidel V. Ramos indicated that he would transform Mindanao into the country's 'economic growth center'. Both Presidents have equally directed that scientific and technological discoveries and innovations shall be actively applied to backstop economic growth and to improve the quality of life of the Filipino.

## BUILDING BLOCKS FOR THE DEVELOPMENT OF MINDANAO

Mindanao has been called the 'land of promise'. It is populated by about 14.8 million Filipinos composed of 18 percent Muslims, 81 percent Christians, and 13 tribal groups. The soil is fertile and the region has been spared of typhoons and floods. It is the only region in the country with numerous natural resources, large arable tracts of land, and well-educated people. It is also in Mindanao where one can find rich nickel and iron deposits; the latter account for three-fourths of the country's iron reserves. Large coal deposits can be found in the northern coast producing sintered iron and steel plates. Mindanao also hoards a third of the nation's coal reserves and two-thirds of the entire island are still covered with forests. Agriculture is very

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pronounced with large multinational corporations like Dole, Del Monte, and United Export companies operating and accounting for about 33 percent of the country's agriculture exports of bananas, pineapple, and tuna. New high-value crops are being produced such as asparagus, tomatoes, onions, mushrooms, and cut flowers. No less than President Fidel V. Ramos has consistently named Mindanao as the country's front door to East Asia, and more importantly, a major player in achieving the government's goal of industrialization by the year 2000. This call was strengthened by his creation of a presidential field office in Mindanao and the appointment of Paul G. Dominguez as Presidential Assistant for Mindanao.

### **The BIMP-EAGA Growth Triangle**

Mindanao has been in the front page news lately not only because of the peace talks between Nur Misuari and the government panel or the peace and order problems brought about by the extremist groups of Abu Sayaf and the MILF. Mindanao has now become known as a new 'battleground' for investors because of the new initiatives brought about by the formation of the **BIMP-EAGA**, the first building block, that would pave the way for the rapid development of Mindanao. **BIMP-EAGA** stands for Brunei-Indonesia-Malaysia-Philippines East Asia Growth Area, a spin off from the ASEAN free trade zone. Besides Mindanao, **EAGA** also comprises the subnational economies of East Indonesia, East Malaysia, and Palawan. The East Asia Growth Area proposes increased economic linkages between member countries and this has served as a take-off point for the full development of business potential in the area.

As a starter, the Philippines is fast tracking the creation of the \$300 million **BIMP-EAGA** Growth Fund in time for its programmed launching by the fourth quarter of this year. The proposed fund is envisioned to serve as a catalyst for the progressive development of approved **EAGA** projects for Mindanao. The investigative study of the Asian Development Bank has identified 25 priority projects to be pursued by this new geo-economic grouping. Four areas have been identified for immediate implementation of cooperative ventures between the **BIMP-EAGA** member countries. They include the (1) expansion of air linkages, (2) expansion of sea linkages, (3) expansion of fisheries cooperation, and (4) joint tourism development. The short-term plans for immediate implementation would include the: (1) promotion of the **EAGA** sub-region as an eco-tourism destination; (2) promotion of the **EAGA** region as a center for agri-processing; and (3) increase in the level of formal trade within the **EAGA** member countries.

Mindanao is pursuing two key development strategies in this regard. The first strategy is to bring about the full physical integration of the cities and provinces in Mindanao. Infrastructure projects are in the pipeline to link the region's 15 million people into a vibrant economic unit and an attractive consumer market. The second strategy is to strengthen the island's trade and economic links through the **EAGA** concept.



Several initiatives have already started in the areas of air and sea linkages, transport and shipping services, fisheries cooperation and tourism development. The expansion of Zamboanga port as a possible cruise destination along with neighboring East Malaysian states of Sabah, Sarawak, and Brunei is a major project identified by an ADB study that will propel the progressive development of the EAGA areas. The completion of the Mindanao arterial road network earmarked at P2.9 billion, involves the upgrading of 11 road networks. Plans are underway to complete a six-lane expressway to link Davao City with Cagayan de Oro and arterial road network to connect airports, seaports, and large cities in Mindanao. This alone will provide access to agricultural, aquaculture, and other products and linkage between the cities and provinces throughout the island. The upgrading of the airport in Puerto Princesa has already commenced for the promotion of eco-tourism since the area is endowed with rich natural resources. With funding assistance from US AID, expansion and modernization of Mindanao's seaport in Makar into a full containerized port, is now in full swing. Another fishing port being developed in General Santos City is under the P589 million project funded by Japan's Overseas Economic Cooperation Fund. The Davao International Airport featuring a runway extension of 3,000 meters is also due for completion this year.

Sometime in March this year, the Mindanao Business Council, together with rural bankers and government and non-government leaders jointly signed a memorandum of support to establish a 100 million dollar Mindanao Fund. This would serve as capital for Mindanao-based enterprises to expand their businesses and effectively respond to the growing economic opportunities in the area. To be officially known as the Growth with Equity in Mindanao program (GEM), it will fund priority projects in infrastructure, telecommunication, tourism, agribusiness, mariculture, financial services, and building materials. Presidential Assistant for Mindanao Paul G. Dominguez announced that the GEM Fund will provide a mechanism where projects for investment in Mindanao can be linked with strategic joint venture partners and extending to them technology transfer assistance. In this way, the Mindanao business community, government and non-government organizations, and local and foreign investors can pool their resources and invest in projects and business activities that are within the BIMP-EAGA initiative.

### **The Zamboanga Special Economic Zone and Free Port**

The second building block that would spearhead the rapid development of Mindanao is the recently approved designation of Zamboanga City as a Free-Port Economic Zone. Originally proposed in 1992 and authored by the Honorable Congresswoman Maria Clara L. Lobregat, Republic Act No. 7903 was signed into law by President Fidel V. Ramos on February 23, 1995. This bill, entitled **An Act Creating a Special Economic Zone and Free Port in the City of Zamboanga** will lay the groundwork for the development of the city and Mindanao. In January of this year, Zamboanga City began to operate as a Special Economic Zone and Free Port with the appointment of Former Mayor Manuel Dalipe as Chairman of the Zone.

Among the provisions of the bill is the declared policy of government to encourage and promote a balanced industrial, economic, and social development through the maximum participation of the local and foreign private business enterprises and sectors. The bill states that the government will endeavor to provide incentives for local and foreign investors, generate employment opportunities, and encourage regional dispersal of industries. In other parts of Mindanao, foreign investors are already being courted, given incentives in the form of tax holidays and exemptions from other taxes. These and more are being considered for the Zamboanga Eco-Zone. Another provision describes the zone as a decentralized self-reliant and self-sustaining agro-industrial, commercial, financial, investment, and tourism center complete with suitable, residential and retirement areas for local and expatriate employees. In this regard, transportation, telecommunications, and other facilities would be set up to attract legitimate and productive foreign investments and to generate linkage industries within and outside of the region.

Based on its location, the city of Zamboanga is the nearest port to most of the ASEAN countries. In addition to this, Zamboanga City has long engaged in 'barter trading' with Sabah, Kalimantan, and other neighboring countries in the area. Barter Trading boomed after 1974 when the Philippines and Malaysian signed a formal agreement to cover trade between Labuan and Zamboanga City. This trading business hit a high peak in the 1980s with about 2 million dollars of goods being exchanged between Filipinos traders and Labuan businessman at any one time.

Zamboanga City as a free port and special economic zone would also be conducive to be developed as a financial center similar to that of Labuan, Malaysia. Senator Raul Roco has already introduced in the Senate certain features of Hong Kong commerce that can be applied to Zamboanga City, in order to attract and provide a favorable business climate for potential investors. By liberalizing the conduct of banking and finance, there would be a stronger linkage between local and foreign investors and will facilitate the flow of foreign savings. Capital and banking services needed to develop the growth area are to be made available. Efforts will also be made to facilitate the movement of people within the EAGA member countries, facilitate the exchange of advisers and experts and technicians, and to minimize or remove legal constraints and administrative barriers to trading, business, and economic opportunities between member countries.

### **Need for Infrastructure Support Facilities**

Zamboanga City, as a Free Port and Special Economic Zone, would need massive development and construction of several infrastructure support facilities.

1. *Improvement of Seaport Facilities.* The present seaport facility can be converted to become a main cargo port for tourists and local travel. A new seaport has to be constructed to accommodate cargo port handling, warehouses, tank farms, containerized and bulk loading facilities, and transshipment facilities. For this development, there will be a need to raise up to 500 million dollars.

2. *Improvement of Airport Facilities.* The present airport needs to be improved to accommodate the incoming flights of bigger airplanes such as the airbus and Boeing 747's. One alternative is to extend the present runway by about 600 to 800 meters. The other is to build a new airport in the East Coast where land is available to receive bigger planes, transporting in and bringing out export products like cut flowers, fruits and vegetables, fish and seafood products. The new airport will also house fueling facilities, domestic flight operations, refrigeration and handling facilities, and maintenance units. The old airport can be converted into a new commercial-industrial center and be developed to become a premiere commercial center of the city. A budget of about 50 to 200 million dollars for a modern and complete airport facility will be needed.

3. *Conversion of the Present Airport to a Commercial Center.* If a new airport is constructed and becomes operational, the present airport could be converted into a new commercial-industrial center. This will help pay for the new airport facility. The construction and development of the new airport and seaport will accelerate development in the west and east coasts and decongest the city proper. The opening up of the city to the west by closing the old airport and the east by the new seaport, will accelerate development in both directions of the city.

4. *Construction of New Roads.* As development outside of the city continues, new roads need to be constructed. Aside from the main highway roads linking Zamboanga City to other cities and provinces, arterial road networks are required to connect the centers to the new ports and the new developed areas in the east and west coast. An arterial network of roads in the city connecting the new center to the new ports and the newly developed areas in the east and the west will require an investment of about \$250 million.

5. *Development of Communication Facilities.* Development of communication facilities will need top priority in the development of the Zamboanga Free Port and Economic Zone. Improvement of the present telecommunication structures need to be made a priority for the PLDT. Telephone direct dialing, international direct dialing, and Fax machine facilities are very much a necessity for investors and business transactions. The same goes true for cellular telephones and electronic mail.

6. *Improvement of Power Supply.* The next important infrastructure project is also power supply. Energy and information are the wheels of trade and business and therefore require major considerations in the overall development plan. On this requirement, Napocor President Guido Delgado signed a contract with local government officials, for the construction and establishment of a P2.8 billion pesos power plant that will provide ample power supply for Zamboanga City and the nearby provinces. The contract, signed on March 28, 1996 calls for the construction of a 10 megawatt diesel power plant worth \$110 million. Similar power plants are scheduled to be established in General Santos City, Mt. Apo, Davao, Iligan City, and Misamis Oriental.

7. *Development of Sub-Industrial Estates.* The next area to be considered is the construction and development of sub-industrial subdivision estates for employees and expatriate workers, businessmen, and investors. The estate would have housing projects, shopping centers, recreational facilities, schools, churches, parks, and other amenities conducive for living in the Eco-Zone.

8. *Development of Agri-Estates.* The Eco-Zone should also consider the development of large-scale agri-estates, which are compatible with small scale individual activities similar to the Comprehensive Agrarian Reform Program. Such estates should engage only in processing agricultural output or adopt program activities involving high-value exportable crops.

### SCIENCE AND TECHNOLOGY AND THE BIMP-EAGA

For the people in Mindanao, the BIMP-EAGA initiative and the development programs and economic projects that it will bring, are expected to alleviate poverty, provide the people with basic services, and improve the quality of life in the urban centers and in the rural areas. The development programs and activities are also designed to make an impact on the national economy of the country as a whole. The areas and potential fields of cooperation between the EAGA member countries include the following: (1) Transportation and shipping services, (2) Fisheries, (3) Tourism development, (4) Agriculture and horticulture, (5) Energy exploration and development, (6) Environmental protection and management, (7) Forestry and timber products, (8) Human resources development, (9) Industry, (10) Institutional arrangements, (11) Infrastructure links, (12) Natural resources development, (13) Services, and (14) Trade and investment.

For a start, the development efforts earmarked for the EAGA projects should include the planning and implementation of priority leading-edge technologies in the following sectors: Agriculture and Food Production, Information Technology, Electronics, and Eco-tourism. In all of these enterprises and ventures, human resource utilization and development are of the highest importance and would need priority status. Local and foreign investments in the above sectors would necessarily need labor and manpower with the appropriate skills and technical training for companies to operate. It has been shown that increase in economic productivity can come as a result of four crucial factors: (1) improved labor quality of which education is the key element; (2) reallocation of resources from less to more productive sectors; (3) better economies for scale; and (4) technological changes or advances in knowledge resulting in better methods of production. To provide a solid base for science and technology implementation, Mindanao needs a highly trained skilled and unskilled work force to respond to the requirements of the different sectors of the economy that would come as a result of the EAGA initiative and the Free Port Economic Zone. Two major strategies can be pursued. The first one is to institute a vigorous and comprehensive transfer of science and technology and commercialization programs for the sectors mentioned. The second strategy is to plan for the ulti-

mate development and training for highly competent skilled and unskilled labor force.

### **Strategy 1. Comprehensive Transfer of Science and Technology**

Mindanao must pursue development foremost in the areas of agriculture, aquaculture, food processing, and forestry. The Region must first attain self-sufficiency in food production before it can compete in the foreign market. There should be a strong move to strengthen the domestic economy and to impose drastic agricultural reforms. Major reforms and strategies should be envisioned to increase productivity in rice, corn, livestock, forestry, and fishery products. The competitiveness of the Region's agricultural products can only come by modernizing farming methods and by shifting traditional methods of farming into a more scientific and entrepreneurial approach. Efforts should be made to provide incentives and technical assistance to small entrepreneurs and cooperatives. Small and medium scale technology ventures should be sustained with adequate training and support given for the adoption and further development of technologies that would benefit agricultural production.

At the same time however, Mindanao must not lose sight of its ultimate target and that is to ultimately produce surplus exports and increase dollar earnings. One of the most profitable areas now is in electronics, communications, and information technology. The short term goal in communications technology is to make every Filipino household a part of the information superhighway. Home computing will be an increasing market and the internet is fast gaining acceptance in the Region. The competitive advantage by which commercial and business applications can be gained through the use of digital technology can be complex but dynamic. The internet highway is just but one of the communications technology that home users, agricultural technicians, local government people, the business environment, students, academicians could benefit from. The returns in investment can be fully maximized with effective use of digital communications. The privatization of the telecommunications industry has already created a competitive marketplace with many investors entering the market.

In the coming decade, the demand for electronic and telecommunication services will increase not only for the world market business but more so in deciding what products and services would be most profitable for the continued development of Mindanao. As mentioned once by Science Secretary William G. Padolina, 'We must concentrate on developing emerging technologies such as laser technology, photonics technology, information technology including software development, biotechnology, microelectronics, genetic engineering, material science, and information networking'. Mindanao can have the technology capability to design and develop the software and hardware to support this telecommunication infrastructure. In due time, when the local needs have been satisfied, Mindanao can supply the global market with the same telecommunication high-technology products. In this regard, Mindanao needs the assistance of the Department of Science and Technol-

ogy and other line agencies to help it achieve a full and effective transfer of technology to speed up the development of priority projects.

Another dollar earner activity for Mindanao is in the promotion of eco-tourism. Mindanao abounds with forest sanctuaries, coastal zones and beaches, mineral grounds, and a rich indigenous cultural heritage that can offer extensive opportunities for tourist attraction. At the same time that agriculture is being modernized to include the application of technological innovations, sustainable agriculture should also be pursued even only in selected sites and areas. Sustainable agriculture does not mean a return to primitive traditional methods of agricultural production. It is a combination of traditional conservation methods with sustainable systems of equipment and procedures. Thus, strategies for a sustainable form of agricultural development must also be underscored. Eco-tourism can be pursued in earnest, but in the course of its development it should include at the same time conservation, protection, and rational use of the island's natural resources. It is essential for policy makers, businessmen, and consumers to take note that if we are to achieve a life of dignity and if the welfare of present and future generations is to be assured, environmental protection should be mutually compatible with economic growth. This implies that economic and developmental growth objectives should not only be for the good of society, but also for the natural dynamics and carrying capacities of the environmental eco-systems.

The development of trade in the BIMP-EAGA region, especially through the ports and commercial centers will boost the tourism sector. The present tourist attractions of Zamboanga City are the golf courses and beach areas. The development in the west coast also make the La Paz and Camp Susana areas potential tourist attractions. With proper development and planning, these two places can be converted into tourist places comparable to if not better than that of Baguio City. Also high on the priority list, is the development of the two Sta Cruz islands which are noted for their pink sand beaches and colorful underwater coral reefs. In the east coast, resorts spanning the coastline of Bolong to Vitali and Taluksangay can be made attractive for tourists. The places are not only noted for their wide beaches but also for their ethnic cultural and historical artifacts and collections.

## **Strategy 2. High-Level, Skilled and Unskilled Manpower Development**

One serious problem that would hinder the growth of any emerging economy is the lack of manpower with the right skills needed to staff the different sectors in agriculture, food processing, information technology, electronics, and eco-tourism. We have too many university graduates who are either unemployed or underemployed as a result of a mismatch of training and job opportunities. Attitudes towards the type of job to be taken can also be a major problem as many of our graduates opt for 'white collar jobs' that are not available. In contrast, there are many opportunities that are left unfilled in the agricultural, industrial, and technical sectors due to lack of manpower with technical skills. To develop and expand our industries in Mindanao, we would need trained skilled workers for they are the backbone of the

different industries that would propel the full development of the area. In many instances, we lose our skilled workers to industrialized countries who offer them better incentives than what they can get in our own country. We should be able to train and retain our skilled and unskilled manpower. To enhance and complement the capabilities of the labor force in the application and promotion of science and technology, several measures should be adopted. For instance, there should be a greater emphasis on human resources development in relevant science and technology areas. Authorities at the Zamboanga Eco-Zone must be able to identify, plan, and provide the products and services most needed and wanted by investors. There must be an in-depth survey of the products and services that would be in demand by local and foreign investors. An inventory of resources and the markets for these will have to be specified. An inventory data bank of manpower resources to indicate what we have and what local and foreign investors need is extremely essential. Continuing training programs on technology and research management should be planned for major program sectors. Research and product evaluation should be intensified to improve labor efficiency and productivity. Global competitiveness can only be attained when quality products are at par with products produced in other countries. In this regard, institutions like State Colleges and Universities should strengthen partnership with the private sector, non-governmental organizations, private colleges and universities, and other relevant government agencies to rationalize course offerings, programs, and resource training initiatives. Inter-sectoral discussions, collaboration, and partnership in providing the most effective and relevant human resource training could be pursued in the areas of networking, information exchange, technology promotion, technology assessment and transfer, and marketing of products to the different parts of the region. In this connection also, Mindanao will continue to seek the assistance of the Department of Science and Technology to provide the necessary support in modernizing and implementing massive technology transfer mechanisms from local and foreign sources in program sectors where S&T are mostly required. Support in manpower development and the development of a science and technology culture among students and teachers would also be needed.

To keep afloat in the 21st century, Mindanao must come up with a comprehensive, systematic, and well-coordinated human resources development plan for its sectoral programs. What we have today are individual and oftentimes uncoordinated policies for Human Resource Development from various sectors. HRD in Mindanao should not only be geared to prepare the people for the influx of economic, trade, and networking development trends as a result of the BIMP-EAGA and the Free Port Economic Zone initiatives. Human Resource Development should go beyond and prepare for the consequences of the transfer of science and technology and its effects on the labor force. Three strategies can be undertaken. First, Mindanao should look at its educational system. Improvements should be made on the factors that affect the provision of relevant quality education in the basic, secondary, and tertiary levels. Incentives for teachers and university academ-

ics, circular reforms, provisions of instructional materials and textbooks, decreasing the present teacher-student ratio in the classroom, subsidies to private institutions, and many other factors should be examined and improvements instituted. Second, continuing professional and technical education and training must be planned for skilled and unskilled workers. Management personnel and technical staff need to be continuously re-trained and re-tooled with the necessary knowledge, competencies, and skills in keeping up with the rapid changes in technology production and marketing economy. Third, there must be a change in the attitude of the people to desire education and training in science and technology courses as well as in skilled courses in manufacturing, construction, communications technology, electronics, and transportation. Historian Paul Kennedy in his book **Preparing for the 21st Century**, mentioned that Japan, South Korea, Germany, the Scandinavian states, and the European Community as a whole are the countries most likely to succeed in the 21st century. The reasons for this assessment are obvious. These countries have a high savings rate per family in the population; public and private levels of investment in new plants and equipment are impressive; and most of all they have an *“excellent educational system, a skilled workforce, good re-training systems and a work culture”* that is most enviable. Ultimately, with an efficient and hard-working skilled and unskilled labor force, Mindanao could adopt a technology-based economic growth similar to the path successfully taken by Singapore and Taiwan. Both countries were successful at developing their technological capabilities because they invested heavily in both education and research and development projects. Also, foreign investors, small and medium scale entrepreneurs, and the private sector were attracted to the incentive structure and environment put up by government for business to prosper.

In due time, Mindanao could create a sustainable competitive advantage of its products and services through the build-up of technological capabilities as a result of an effective manpower labor force. As Paul G. Dominguez, the Presidential Assistant for Mindanao, once remarked, “The best has come to Mindanao and the island will be prepared for it”. With proper planning and implementation of target plans plus support of the government and private sectors, Mindanao can be transformed from a *“supplier of raw materials that it had been for so many decades, into a balanced agro-industrial and service-based economy”*. There is a strong future ahead for Zamboanga City and Mindanao in general, but nobody is going to pick up the cudgels for development except its people. Working together in unity, with utmost personal freedom and social responsibility to put matters in the right perspective sans greed and selfishness, the development of Mindanao can be attained to the fullest.



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## Panelists

**AMELIA C. ANCOG, Ph.D.**

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At the outset, allow me to congratulate Fr. Bomeisl and Dr. Alvarez for the excellent paper on the Role of Science and Technology in the Development of Mindanao. The paper has presented in a very clear way the current infrastructure developments in Mindanao, the role of the East-Asia Growth Area (EAGA) and the expected inputs of the Department of Science and Technology that will accelerate the technological development of Mindanao.

As pointed out in the paper, the potential areas of cooperation among the EAGA member countries encompass the following: Transportation and shipping services, Fisheries, Tourism development, Agriculture and Horticulture, Energy exploration and development, Environmental protection and management, Forestry and timber products, Human resource development, Industry, Institutional arrangements, Infrastructure links, Natural resources development, Services, and Trade and Investment. However, the authors propose that priority be focused on technologies relating to agriculture and food production, information technology, electronics, and eco-tourism.

### **A. Areas for Development**

I can not disagree with the suggestions of the authors for indeed these sectors may be considered as sunrise sectors which can enhance Mindanao's production of globally marketable products and services. For instances, Mindanao has tremendous food resources which, properly processed according to international standards, can penetrate the wide markets in various parts of the world. In fruits alone, Mindanao produces not only one of the best pineapples in the world. It also produces exotic fruits such as durian and rambutan which can be easily marketed in the Middle East and European Countries; both in their natural and processed forms.

The abundance of fish and other aquatic products is also a distinct advantage of Mindanao. Increasing the production of these commodities will not only meet the demands for domestic consumption but also that of export requirements.

**B. Investments Level**

It will be noted that there are substantial investments in the region for 1993 and 1994 as shown in the following table:

BOI-approved New and Expansion Projects  
Regional Distribution, 1994/1993

Region	Value of Investments (in billion pesos)	
	1994	1993
9	10,733.1	332.0
10	15,671.1	21,287.0
11	4,477.8	4,647.0
12	6,371.1	-
<b>TOTAL</b>	<b>37,253.1</b>	<b>26,266.0</b>

Source: 1994 Annual Report, Department of Trade and Industry.

**C. Technology Transfer Programs**

The authors propose that DOST assist in technology transfer activities as well as in providing support for human resource development. As many of you are already aware, the DOST has a number of programs which are intended to hasten technology transfer with the active collaboration of experts from the academic institutions and the private sector as well. These programs include the following: the Manufacturing Productivity Extension for Export Promotion Program (MPEX) assists small and medium enterprises (SMEs) in the manufacturing sector to attain higher productivity and the Municipal Science and Technology Advisory Program (MSTAP) aims to promote technology-based enterprise development in the countryside by tapping academic institutions in the delivery of technology assistance. The Department of Science and Technology (DOST) through the Technology Application and Promotion Institute (TAPI) provides funds to cover travel and other incidental expenses of experts from selected colleges and universities, and the Science and Technology Experts Volunteer Pool (ST EVP) brings the scientists to where they are needed – the countryside. The services of experts are made available for free for very short term technical assistance to cooperatives, NGOs, and other interested parties.

**D. Technology Transfer Projects**

It will also be observed that for Region IX technology transfer projects include the following: marble processing, rice hull combustor, multicrop solar drier, coconut oil processing, woodwool cement board, and coconut processing. For Re-

gion X, the following projects were implemented: ceramics production, banana processing, furniture development, metals development, marine fisheries development, brick making, laundry soap making, production of energy from non-conventional sources, shrimp and prawn waste processing, production of equipment for gems and gemstone and fashion jewelry, production of industrial ceramics, rubber wood processing, production of cutflowers through tissue culture, rapid composting (organic fertilizer production). For Region XI, the following projects are being implemented: mango processing, gemstone processing, coconut coir production, utilization or conversion of municipal waste, pearl production, structural bricks production, coco coir production, ceramics production, woodwool cement board production, meat and fish processing, coconut veneer production, and seaweed production for phycocolloid extraction. For region XII, the projects involved are: gemstone cutting and processing, integrated coconut precessing, biomass tissue culture. For Region XIII, the following projects are being implemented: aquaculture and prawn hatchery, beads jewelry production, dimension stone production, butterfly rearing, and multi coconut product processing, and technology for waste management.

Majority of the projects are agriculture-based. Thus, there is a need to develop projects which are along high technology areas such as information technology and biotechnology. In addition, projects of industrial nature have to be encouraged to enable Mindanao to fast-track its progress.

Officers of our Provincial Science and Technology Centers who have been collaborating with the different agencies and institutions in Mindanao are quite active in technology transfer activities. However, because of limited personnel, only one officer is assigned in each province. We believe that a closer relationship among the private sector, the academe, and the NGOs in technology transfer activities will hasten economic development. We, therefore, urge you to collaborate with our PSTC officers so that your needs can be addressed by the regional offices and the central office of DOST.

#### **E. Human Resource Development**

You may wish to know that in so far as human resource development is concerned, the DOST is implementing the Engineering and Science Education Project (ESEP) which hopes to produce 3,000 graduate and post graduate scientists and researchers by the year 1998.

In addition, the various training programs and scholarships supported by the Philippine Council for Advanced Science and Technology Research and Development (PCASTRD), Philippine Council for Industry Energy Research and Development (PCIERD), Philippine Council for Health Research and Development (PCHRD), Philippine Council for Agricultural Resources Research and Development (PCARRD), and Philippine Council for Aquatic and Marine Research and Development (PCAMRD) hope to augment the supply of scientists and technologists. As of December 1995, these councils had supported 135 scholars and 1,953 trainees. The Science Education Institute also supports 3,500 scholars at the tertiary level who

come from the poor families nationwide. Similarly, it also funds and extends technical assistance in the training of teachers in science and mathematics through the Regional Science Training Centers (RSTCs).

There is now pending in Congress, a bill that will increase the funding for S&T Scholarships for the poor but deserving young Filipinos who are in the top five percent in their class and who pass a national competitive examination. It is our hope that this bill will be passed this year so that we can increase the number of young scientists in the country. To date, there are 1,116 scholars from Mindanao who have successfully hurdled the competitive examinations and who are now enrolled in technical and other courses leading to a diploma or to a bachelor's degree in science, mathematics, or engineering.

As you will observe, there are many Centers of Excellence in Mindanao and they are staffed with very competent faculty members. Nevertheless, there is a need to continuously upgrade the capability of the faculty and these institutions through the installation of the most modern laboratory facilities so that the education of the scientists and technologists will take place in an environment conducive to scientific learning.

You may wish to consider that Mindanao can be the site of centers of excellence to enhance the educational advancement in science and technology of students from the EAGA countries. We feel that certain institutions in Mindanao can already fulfill this important role for some of them are already known internationally and have produced very good scholars and scientists.

The authors propose that DOST support massive technology transfer activities from local and foreign sources. Such support is already available under the Global Technology Search Program.

We encourage you to consider utilizing this window of opportunity for very focused technologies that you think will be useful in the development of Mindanao. We will be more than happy to assist deserving applicants who comply with the criteria of DOST.

We hope that the assistance in the future will be focused more on the increased production capability of Mindanao in food processing, information technology, materials science, and biotechnology. There are major programs of DOST in these areas including research and development projects. We hope that you can consider this in the development of your research and development plans and technology transfer activities.

As we look forward to the 21st century, we need to go beyond the shores of the Philippines and see Mindanao's role as the Center of Learning for the EAGA countries. We can be truly proud of our talented faculty members, our energetic private sector, and our open culture which welcomes all creeds and nations with a hospitable perspective. We are aware that we have a tremendous capacity for teaching and reaching out to other peoples of the world; that we know how to interface with peoples of various persuasions and beliefs; that we are adaptive and flexible and can succeed in the most adverse and most favorable environments.

Finally, may I extend my best wishes and congratulations to the academicians and scientists who are now meeting in Davao City. We believe that your meeting will be productive and will have quality recommendations and decisions which DOST can consider.

Thank you and good day!

**FILEMON G. ROMERO**

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At the outset, I would like to greet the paper presenters, my fellow panelists, the academicians, scientists, and all those present with the universal greeting peace, *Assalamu Alaikum warakmatullahi walbarakat*. I would also like to thank the National Academy of Science and Technology for inviting us from the Mindanao State University-Tawi-Tawi College of Technology and Oceanography to participate in its 18th Annual Scientific Meeting. It is just unfortunate that the original panelist, our Chancellor, Prof. Eddie M. Alih, is now in the Middle East countries together with our honorable Congressman Nur G. Jaafar trying to solicit funds to finance the development plan of the Southern Philippines Center of Islamic Studies, a center which I established during my incumbency as Chancellor. I would like to speak briefly about the MSU-TCTO, its mandate and role in science and technology and in promoting peace and understanding between Muslims and Christians.

First, I would like to congratulate Fr. Bomeisl and Dr. Anicia A. Alvarez for coming up with an excellent paper on the role of science and technology in the development of Mindanao. As a reaction to the paper, I would like to suggest a more focused dimension to the two strategies they recommended, that is, that the investment of the country's limited resources should be in the development of technologies in carefully selected resource-rich areas. This strategy for localization and specialization was adopted in Korea in its process of industrialization.

While the DOST considers this as one of its mandates, one of the major setbacks of S&T, not only in Mindanao but throughout the country, is that the S&T development plan has not been backstopped by sound legislations and sufficient funding. Direct appropriation to S&T is less than 1% of the Gross National Product in contrast with other countries which earmark 3-5% of the GNP to this priority agenda of development. Table 1 shows the national scenario and the figures may even be lower for Mindanao.

**Table 1. Regional S&T operations (in thousand pesos)**

Regions	93	94	95	96	Total
IX	6,302	5,002	5,490	7,205	17,517
X	8,024	4,741	6,506	9,362	20,609
XI	7,305	4,661	4,209	11,452	20,322
XII	6,316	3,901	6,474	5,895	16,270
Sub-Total	27,947	18,305	22,679	33,734	74,718
Total	96,065	57,872	71,176	111,216	240,264
Percentage	29.1	31.6	31.9	30.3	31.1

Likewise the funds intended for assistance to science and technology research and development are very limited. Moreover, this allotment includes expenditures such as salaries of regular staff, not necessarily research staff, and maintenance and other operating expenses. These funds are used more for maintenance of the office rather than for funding research activities so that very little impact can be achieved in R&D. Distribution of the allocation for science and technology assistance to the four regions in Mindanao is shown in Table 2. The appropriation for science and technology in the Autonomous Region for Muslim Mindanao is incorporated in the Office of the Regional Governor.

**Table 2. Assistance to science and technology R&D (in thousand pesos)**

Regions	93*	94	95	96	Total
IX		3,211	4,914	6,157	14,282
X		3,883	5,620	7,151	16,654
XI		3,465	5,204	7,875	16,545
XII		3,147	4,851	6,130	14,128
Sub-Total		13,706	20,589	27,314	61,609
Total		46,970	70,925	92,889	210,784
Percentage		29.2	29.1	29.4	29.23

\*No figures were given in the original paper.

There is therefore a need to provide S&T with aggressive policies and legislative action. One of these is the establishment of specialized research centers in Mindanao for carefully screened resources abundant in the area and with high commercial importance. There will be not only adaption of existing technologies to this need but also generation of new technologies. These centers will provide an

avenue for synergy of efforts/teamwork among scientists. By giving full support to these specialized research centers engaged in R&D activities and technology generation for industrial and other applications, Mindanao will be able to meet the challenge in providing the lead for the BIMP-EAGA region in agro-industry, construction and construction materials, and fisheries cooperation, the thrusts of Mindanao in the newly created growth area.

These designated research organizations should be given high priority for investment in facilities and manpower development. In support of this move, a pool of creative scientists and high caliber technologists should be nurtured. Such is the role of DOST with its sectoral councils, such as the ESEP, PCAMRD, PCASTRD, PCIIRD, etc., in nurturing young scientists for key roles in the academe, in industry, government agencies, and research organizations. The DOST has embarked on an aggressive program to develop a critical mass of R&D scientists and researchers for the country and a large number of these potential scientists come from Mindanao with the hope that they will return to Mindanao. However, if the research facilities and opportunities for advancement in their chosen fields will not be available, these scholars will seek better opportunities abroad, resulting in brain drain.

While state universities and colleges have a critical role for the development and training of a highly competent skilled and unskilled labor force and more importantly, contribute to R&D, they are unfortunately provided with insufficient funds. Much as they would want to pursue the goals of supporting the science and technology development thrusts of the national government, their research services funds are inadequate or even wanting as shown in Table 3.

In Region IX out of six SUCs, only three have funds for research services but these allotments are not purely direct cost to research but include personal services and other maintenance and other operating expenses. Actually, a very small portion of the research funds goes to the direct cost of research. The same is true with the other SUCs in Regions X, XI, and XII.

To remedy this situation, one such specialized center has been proposed by Dr. Nemesio Montano and Dr. Gavino Trono, noted seaweeds scientists from the UP Marine Science Institute, namely, the Seaweed Research and Development Center. This should be established preferably in Bongao, Tawi-Tawi which is the primary producer of eucheuma seaweeds, the source of carrageenan, a phycocolloid widely used in the food and pharmaceutical industries. This center shall include a seaweeds seedling bank in order to maintain in culture under strict laboratory conditions the best strains of economically important seaweeds thereby ensuring the best quality carrageenan-producing strains. Another component is the seaweeds quality control laboratory designed to monitor the quality of seaweeds used as raw material for carrageenan extraction. With the acceptance by the European Economic Community of Philippine National Grade (PNG) carrageenan as food additive, there will surely be an increase in demand for this source of this phycocolloid. Similar specialized research centers for rubber, tuna, cassava, and exotic fruits should likewise be established in strategic areas.



**Table 3. Investment in research services among SUCs  
(in thousand pesos)**

Regions	93	94	95	96	Total
<b>REGION IX</b>					
WMSU	714	791	1356	1759	4620
TCTO	2233	2235	2262	2615	9344
ZSCMS	467	520	1320	1197	3504
BSC			50	80	130
SSC			50	50	100
TRAC			50	50	100
<b>REGION X</b>					
CMSU	1512	3109	2397	3504	10522
MP SCT	468	467	1004	631	2570
BSC			50	86	136
NORMIST			50	112	162
MOSCAT			50	50	100
<b>REGION XI</b>					
USP	1137	1008	929	1146	4220
DOSCT			50	315	365
SPAMST			50	65	115
<b>REGION XII</b>					
MSU	10321	12321	11123	17219	50984
MSU-IIT	2229	2351	7655	4354	16589
USM	6646	6618	6655	7322	27241
CCSPC			50	50	100
CFCST			50	50	100
SKPSC			50	50	100

The Mindanao State University System, for example, in support of the Science and Technology Agenda for National Development of DOST and having been identified as a lead educational institution in the BIMP-EAGA, has classified commodity centers for science and technology R&D: For MSU-Marawi, cutflowers and root crops; MSU-IIT, alternate building materials; MSU-Tawi-Tawi, seaweeds; MSU-General Santos, tuna; MSU-Naawan, abalone and crab culture; and MSU-Sulu, cassava and exotic fruits. However, with very limited research funds very little impact for the advancement of science and technology can be achieved.

While the paper has recommended the promotion of Mindanao as an eco-tourism center, it is however very important that the conservation of biodiversity be considered. Biodiversity conservation should be backed up by strong scientific

guidelines and not just by pure advocacy. Efforts should be supported with scientific information otherwise, the fragile environment which is earmarked for development as an eco-tourism attraction will be imperiled.

After decades of thorough studies by Philippine and Malaysian scientists on the biology and ecology of marine turtles and the nature and responses of small island ecosystems, the Philippines and Malaysia signed recently a bilateral agreement for the joint management of the Turtle Islands Heritage Protected Area. This comprises three islands on the Malaysia side and six on the Philippines side. These islands are known as major breeding and nesting grounds for green turtles (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*). This agreement treats the nine turtle islands as a single conservation unit to be covered by a comprehensive conservation and management plan because the turtles in the area constitute one population of marine turtles. A component of this plan would make these islands as a model eco-tourism center where the resources would be well managed and the fisheries enhanced. Before the Turtle Islands of the Philippines and Sabah were declared as a marine reserve or a heritage protected area with the assistance of the World Wildlife Fund, there was sufficient scientific basis for decision and the management plan that was adopted. The continuous monitoring of the resources and evaluation of the management plan was also provided for.

I would also like to bring to the attention of this scientific body an emerging problem. The BIMP-EAGA region is within the center of the world's marine biodiversity but the extensive reef systems within the BIMP-EAGA region are facing a serious threat from the use of destructive methods of fishing, particularly the use of dynamite and of sodium cyanide. There is a need to come up with a concerted policy to check these practices in order to preserve the integrity of the coral reef ecosystem in the area. Coral reefs are not only favorite ecotourism spots because of the diversity of fauna and flora that these reefs support but also because they serve as spawning and nursery grounds of fishes. Hence, if these reefs are degraded, the fisheries in the entire region will not be secure.

I wish to close my reaction with the quotation from a famous scientist, "science and technology should graduate from one merely supporting national economic development to one directing this development towards the establishment of a technologically self-reliant society" and, I might add, for a more dynamic Mindanao. Thank you and *wassalam*.

**JULIETA I. ORTIZ, Ph.D.**

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I wish to focus my reaction on what I perceive is a dimension common to both the BIMP-EAGA concept and technology transfer and adoption – the sociocultural dimension.

I will start by introducing you to a little study I made on the perceptions of 60 farmer cooperators in Davao Oriental on the BIMP-EAGA. The subject cooperative is one of the most progressive cooperatives in the Region. I did this study to illustrate that very little is known about the BIMP-EAGA in rural communities, a development strategy born in early 1994.

The study revealed that only eight out of sixty respondents claimed they heard about it. Most of them heard about it through radio, print TV, and two from some line agencies. Only one claimed he heard about it from a teacher while two from NGOs. Four claimed it was "pro-poor".

All eight included in their choices all the right concepts about BIMP-EAGA but four of them thought it was also a peace-keeping treaty. One thought it was also to unite member countries under one government. All eight, however, thought they had a role to play in promoting the BIMP-EAGA strategy.

Undoubtedly, the majority of the absolutely poor live in rural areas. Even for that reason alone, it is proper for any development policy to give high priority to rural development. It should integrate the poor into the overall socio-political and economic system. If it does not, the concept is in danger of becoming merely an acronym, a catchword or a slogan like many other well-meaning development policies.

Apparently, it is too early to venture to pass judgment on the BIMP-EAGA. To date, meetings, fora, and the like have been conducted mostly at the upper echelons of government bureaucracies of the member countries.

As to how the BIMP-EAGA would specifically address the needs of the rural poor is little known at the moment although it is intended to benefit the total population. As conceived, it may succeed in raising the nation's GNP. The big-business and developed-country orientation however of BIMP-EAGA could marginalize the poor. In the drive for economic growth, a worsening of income distribution may follow. The same orientation seems to rely greatly on the trickle-down effect of development to bring about economic growth. Historically, this concept has not significantly succeeded in alleviating the lives of the poor in developing countries.

Additionally, we should be wary of the fact that, in this context, apparently the poor do not share in the product of economic growth. As such, we can assume that the poor do not contribute significantly to socio-economic development. They simply execute development activities.

On the subject of technology transfer and adoption, advances in modern researches and technology for agricultural production are not easily accessed by ordinary farmers. Commercialization of use of these researches involves, more often than not, the importation of inputs and expenses for machineries which ordinary farmers cannot afford.

This brings us to the subject of "appropriate technology". The then deputy permanent secretary of the Ministry of Education in Thailand, Saiyut, Champatong, defined it so well as the "...social dimension of innovation ... that the value

of technology is not only in its economic viability and technical soundness but in its adaptation to local social and cultural environment.” This definition implies that the assessment of technology requires some sort of value judgment both by the developer and the user. Simply translated, the choice of a technology must be applicable to local conditions. Thus chosen, it becomes “appropriate technology”.

Hubert Kotter once said that the continued marginalization of small farmers is in part due to a deficient cognitive ability and to lack of communication – which means that the farmers cannot adopt what they cannot understand. This therefore implies that a development policy should adopt a package of effective communication and a system of delivery – which seem inadequate in our present technology-transfer activities.

The reason why low-cost technology is much more difficult to publicize is because there are no clearly established or effective communication channels in order to reach target groups. People, particularly rural folks, generally do not know about low-cost technology. Characteristically among rural populations, the demand for it does not arise independently.

What, therefore, is the primary task of government in relation to S & T in the development of Mindanao? The task at hand is to make rural poor communities know that appropriate technology exists and can be developed to help them improve their lives.

Government therefore should create, nurture, and rehabilitate the internal capacity of our people to invent and innovate. No one can refute the fact that development rests in large part on the internal innovative capabilities of a society. For us, this would mean that we should not only be more selective in the choice of imported equipment, plants, and methods of production; we should also invent and diffuse new technologies as well as forms of organization which are better suited to our local conditions.



## **PLENARY SESSION V “ADDRESSING MINDANAO’S HEALTH PROBLEMS”**

### **Proceeding from Discontent**

**ALFREDOR.A.BENZON, M.D., M.B.A.**

*President and Chief Executive Officer, The Medical City  
Vice President for the Professional Schools and Social Development  
Ateneo de Manila University*

Let me begin by expressing my appreciation to your President, Dr. Conrado S. Dayrit, and the National Academy of Science and Technology for extending me this invitation to address you this morning. I am particularly honored by the presence of some of my teachers and mentors as well as comrades and colleagues in past and current ventures.

I recognize that you come from different places and perspectives. Some of you are from Mindanao, others are not; some are from the health sector, others have different interests. In crafting this address I hope to act as a catalyst for the generation of common understandings. On this particular occasion, the challenge is finding that common ground among the diversity of interests and concerns present today.

Those in the health sector of Mindanao may be concerned that their health status lags behind the national situation. This they may attribute to the low prioritization of Mindanao, and relate the solution of their health problems to uplifting the status of the region. Those from the health sector outside of Mindanao may believe that the problems of health are rooted in sectoral rather than regional concerns, that is, that the health sector does not receive the priority it deserves, and that therefore it is the status of the sector in its entirety that must be uplifted. Those outside the health sector – the scientists and academicians, among others – may feel the need to understand the role that they can or should play in this whole process. Thus, given this wide range of the concerns and expectations, perhaps what is needed is a road map that captures these different starting points towards a shared destination.

This morning, then, I would like to suggest some ideas that might serve as *guideposts* in our shared journey. These guideposts may look different from different angles of the journey; but at the end, they will hopefully help us long the path to the our common destination.

**The first such guidepost is perhaps understanding that Mindanao, and the challenges it faces, is a microcosm of the challenges of national development.**

Our country has been tagged as "the sick man of Asia," a dubious distinction that we seem to have difficulty overcoming. From 1980 to 1992, our per capita GNP declined by an average rate of 1% per year. In sharp contrast, average annual growth of per capita GNP for Indonesia was 4.0%; Singapore, 3.5%; Thailand, 6.0%; China, 7.6%; and South Korea, 8.5%. For 1996, real GDP growth for the Philippines is projected at 5%, a definite improvement from past years' performance. However, this continues to lag behind Indonesia's 6.5%; Singapore's 7.0%, and Malaysia's and Thailand's 8.0%. Our unemployment rate for 1994 was 9.0%, way beyond Indonesia's 3.5%, Thailand's 3.1%, Malaysia's 2.7%, and Singapore's 1.5%. Not surprisingly, the state of our people's health is likewise inferior by Asian standards. Life expectancy in the Philippines has been estimated at 64 years, poor in comparison with 69 years for Thailand, 71 years for Malaysia, and 75 years for Singapore. Similarly our infant mortality rate per 1,000 was established at 40, once again dismal compared to Thailand's 26, Malaysia's 14, and Singapore's 5. Our characterization as "sick", therefore, seems to apply both figuratively and literally.

As the Philippines has fallen behind its Asian neighbors, Mindanao has fallen behind the rest of our country. In 1988, poverty incidence in the Philippines was estimated at 45.5% of the population. By 1991, this had declined to 44.5%. Poverty incidence in Mindanao, however, increased from 46.4% in 1988 to 53.2% in 1991. This relative poverty of Mindanao has had unfortunate consequences on the state of its health. From 1986 to 1990, life expectancy in the Philippines averaged 64.0 years, while infant mortality per 1,000 live births averaged 52.8. Over the same period, life expectancy in Mindanao was at 55.8 years, while its infant mortality rate was 90.8 per 1,000 live births. In 1992, the maternal death rate of the country was 0.82 per 1,000 live births; for Mindanao, the rate was double the national average – 1.61 per 1,000 live births.

The dynamic relationship between a community's health status and its state of economic development has been the subject of much study and debate. That such a relationship exists however is beyond dispute. Addressing our regional and national health problems then is closely and inextricably intertwined with the attainment of our development aspirations.

Yet this process has been elusive, protracted, and thus frustrating. Why is this so? It is certainly not due to a lack of resources of our land, which remains as rich as those of many of our more developed neighbors, or even more so. Neither is it due to a lack of resources of our spirit, which continues to exhibit the same resiliency and desire that has so often sustained us in times of crisis. I have often pondered this

question and have come to a realization that where we have come short is in harnessing our human resources, in cultivating the capabilities of our people such that our land becomes fruitful and our spirit productive.

**This then is the second guidepost: that the breadth and scope of the challenge of development demands a response that is people-centered.**

Our paradigms for development have been focused primarily on hardware – infrastructure, facilities, equipment. Yet these are merely instruments. Our approach to development must be led by the development of our human resource, one that has, as its heart, the advancement of the capacities of the people that enable, enliven, and ennoble the instruments.

Many of those steeped in the technical disciplines may, when confronted with this proposition, assume that they themselves would be excluded, believing that they have already attained the desired level of expertise or competence. After all, most have had years of training and a string of initials after their names to prove it.

However, what I propose is not merely the development of competence, but rather the development of *cross-functional* competence. Our times dictate that we journey out of the confines and comforts of our own disciplines, and become conversant in a broad range of fields – information technology; management, economics and finance; human operations and relations; politics and government. This would require us to master a wide range of associated skills – technical, conceptual, programmatic, organizational, and political. More importantly, we would need the ability to apply, relate, and integrate these competencies across a breadth of activities – information gathering, decision making, policy formulation, program implementation, and organizational management. The activities themselves may be familiar. However, the true challenge lies in proceeding through these activities interactively, that is, in a manner that brings us together and enables us to orchestrate the various dimensions of our expertise and interest.

Unfortunately, in contrast, the reward structure of our society, and hence the orientation of our education, places a premium on specialization – by field, by sub-field, and by sub-sub-field - this possibly approaching ridiculous proportions. Furthermore, training has been aimed at the development of analytical skills – where, in the pursuit of understanding, things are broken down and taken apart. Little import has been accorded to the development of those skills that enable one to integrate and synthesize.

This is particularly characteristic of us in the medical profession. We focus on technical proficiency as the standard of excellence. We strive to gain deeper and deeper expertise, yet we succeed only in gaining narrower and narrower perspectives. We face the danger of fragmenting our patient into a collection of symptoms, as we move farther and farther away from remembering that the object of our concern is not merely a set of disordered systems but a human person.

Furthermore, we focus on the individual patient rather than the community of which he is part. Yet logic dictates that treating a patient with a communicable



disease, for example, necessitates equal and equivalent attention to the home and the workplace from which he came and to which he will return. I believe that one major reason why TB continues to be a national shame, despite general awareness of it by our people and the availability of effective treatment methods, is because of the wall that has been erected between personal care and community care.

Perhaps this is why we in the health sector, and indeed the scientific community as a whole, are not accorded the ascendancy that we so rightfully deserve. We may arrive at our notions using disciplined scientific means. We may be selfless and dedicated, industrious, and imaginative. But even if our cause is just, our hearts pure, our service vital, we find critical gaps between the primary of our vision and the inferiority of our reality.

My diagnosis is that we may, in fact, be suffering from terminal egocentricity, that is, a closed-minded belief that the essential righteousness of our cause, the propriety of our methods and the soundness of our expertise are and should be the only ingredients necessary to advance our state. We have been content to live in our own small world, safe with our concepts, secure with our technology, conversant in our jargon, and comforted by the nobility of our cause. In our desire to be self-sufficient, we have become self-absorbed; and our safe, sanitized world has become a prison. For example, we have been shy and timorous, unconcerned with, and perhaps even disdainful of dirtying our hands in the world of *realpolitik*, even when this is often the arena where battles for recognition and resources are waged and won. Our self-imposed seclusion has restricted the development of competencies beyond the specific sphere of our expertise. This has, ironically, circumscribed our abilities, making us turn inwards, rather than upwards and outwards.

Davao was instrumental in my own personal awakening regarding the value of broader perspectives, those that transcend sector and discipline. I made my first provincial sortie as Secretary of Health to Davao in April 1986. This was upon the urgings of Chito Ayala who conveyed to me that the people, having come down from the "highs" of EDSA, were now becoming restive to see and feel the benefits of the reforms for which they had fought. I listened to their grievances – the lack of medicines, the lack of health personnel, the lack of health facilities – and wondered how these could be addressed, particularly given the sorry state of the government that we had inherited from the dictator. It was through these reflections that I made an important realization – that health was not merely the sum of various technical considerations, but could be a potentially potent political tool to serve well and govern effectively. For health, being a basic, common, and primal good, with concrete manifestations and appreciable benefits, could be the means through which the Aquino administration would make an immediate, actual, and enduring impact on our people's lives. I took these arguments to the President and subsequently received an additional budgetary allocation, this at a time when the other departments were being mandated to tighten their belts.

**My third guidepost is that people-centered development must be institution-driven.**

In developing countries where resources are meager, the prime concern becomes individual survival. This is dangerous on several counts. First, it encourages isolation. This is just as true of the rich, who build walls to protect what they have accumulated, as it is of the poor, for whom survival is the only command. Second, the need to survive promotes short-range, piecemeal, quick-fix approaches to what are essentially long standing, structural, and endemic problems.

These two ill effects of the survival imperative – isolation and short-term thinking – are precisely the opposite of that which is required to assure the sustainability of development initiatives: cooperation in the pursuit of long-term solutions to the development dilemma. This then finds concrete expression in the building of institutions, particularly those which are directed at human resource development. For such an endeavor, if it is to be realized to the extent and of the nature previously described, can only be organized, supported, enhanced, and sustained in an institutional context.

Mindanao does not lack for bright persons, or successful entrepreneurs, or profitable businesses. Neither does the country as a whole. Yet these cannot operate in isolation. Institutions are required to ensure that these persons and enterprises exist and persist. These institutions should seek to become centers of excellence that cultivate the breadth of competencies required by our time, adopting intersectoral and interdisciplinary, yet integrative and interactive approaches to teaching, learning, and practice.

In addition, these institutions should operate as a network, collectively serving as the vehicle through which the base of knowledge, skills, and values is clarified, communicated, and enriched. The “lone star” model of institution-building cannot and should not prevail.

Finally, it would be unwise to merely transplant foreign, often Western, institutional archetypes and force fit these to the Philippine setting. Rather, institutions created should be rooted in and reflective of that which is unique in our tradition, experience, and situation. The implements of technique and technology, Western though these may be, can then be grafted on and adopted in a manner that is appropriate and beneficial.

It would not be surprising – though certainly ironic – if Mindanao, which has become infamous for its level of tension and discord, would be the catalyst for the initiation of this undertaking which is founded on cooperation trust. Often, the impetus for change is born out of a rising level of discontent. The response to that discontent is to either come closer together, by building institutions aimed at reform, or to pull further apart, by fragmenting, and possibly destroying, the old order. This is the precise challenge that Mindanao now faces. Perhaps the creation of structures and systems geared towards human resource development could be the venue through which Mindanao comes together rather than comes apart.

One final note. Capacity-building is generally not viewed as “center-stage” material among those who make and move moneys. The returns take too long. The benefits are difficult to touch, to measure, to project. In PR language, it’s not sexy enough. Notice, however, that the nature and quality of that which ultimately assumes center stage is, of necessity, a function of the capacities of the people responsible for its production and presentation. It is in this context that investments in the human resource, and in institutions geared towards such, emerge as a critical and immediate imperative.

We are not going to reach these goals overnight, over a year, or even over a term. So we must have the patience, perseverance, and perspicacity, for it is only by breaking out of the confines of our narrower interests and inclinations, by tearing down the imprisoning walls of dogma, doctrine, and discipline that keep us apart, by gaining comfort in and appreciation for each other’s worlds, that we can begin to come together and move forward as a sector, as a community, as a region, and as a nation.

## **Panelists**

**DANDA N. JUANDAY, M.D.**

*Quezon Avenue, Cotabato*

My former boss in the Department of Health, Alfredo R.A. Bengzon; Fellow Panelists, Scientists, Academicians, Ladies, and Gentlemen.

The paper "Proceeding from Discontent" was perfectly presented in that it clearly discusses "guideposts" to direct solutions to the age-old problems of health in Mindanao in relation to national development.

The Medical Mission Group Hospital and Health Services Cooperative Philippines (MMGHSCP) was basically formed out of this discontent. With the failure of the government to provide the necessary health services here in Mindanao, a Davao group under Dr. Ting Tiongco started this cooperative in 1982.

We believe that our country is "the sick man of Asia"; we have lagged behind our neighboring countries in almost everything including health. In this area, Mindanao is badly neglected. Dr. Bengzon says that it is certainly not due to a lack of resources in our land. We are rich in natural resources and we have sufficient technical know-how at the desired level of expertise or competence.

We strongly agree with Dr. Bengzon that our approach to development must start with the development of our human resources, an approach that has at its heart the advancement of the capabilities of the people to the fullest.

The MMGHSCP believes that its strength stems from the geographical location and administrative distance of Mindanao from Central Government – Manila. Because of this, doctors realized that they had to pool their resources, be self-reliant, and the Davao Cooperative was formed to answer the basic needs of health.

The basic ideas presented by Dr. Bengzon are within the framework of the MMGHSCP.

Thank you very much for your kind attention and I also thank the National Academy of Science and Technology for inviting me here.

**MISSOSONY J. CHIN**

*Director, Institute of Primary Health Care (IPHC)*

*Davao Medical School Foundation*

*8000 Davao City*

It is always a pleasure to listen to Dr. Alran Bengzon. It is an honor to be asked to serve as a reactor to his scholarly presentation to the body particularly his views of the need to understand Mindanao if we are to face the challenges of changing the view that the Philippines is the sick man of Asia.

In the Mindanao Task Force for Poverty Alleviation (MTFPA), we are constantly faced with the question: How can most of the poor benefit from all the development initiatives?

The presentation of Dr. Bengzon indicates that institutions have to be involved – poverty alleviation will have to involve not only individuals but also institutions.

Can those who are in the field of science and technology bring benefits of improved technology to enable the communities to improve in a manner that the people in the community can understand and manage for itself?

The MTFPA is in the process of demonstrating that computer technology can be linked to some technologies to fight poverty.

My main question is to what extent can Mindanao set the model for extending benefits for the poor, its main goal, its main basis for measuring its own effectiveness.

Dr. Bengzon speaks of a “people-centered response”. This, to my mind, is the main challenge, not just a response that is designed by specialists and scientists for the people but one that involves them from design to implementation to monitoring and evaluation.

This, my fellow Mindanaoans, is a major question that I hope you can tackle.  
Thank you.

## **RECOMMENDATIONS**

**WHEREAS**, the people of Mindanao are of varied origins, cultures, and religious beliefs,

**WHEREAS**, their active participation and co-existence are essential ingredients in the promotion of peace and development,

**WHEREAS**, conservation of natural resources and development are often at cross-purposes and should, therefore, be properly managed to attain sustainable development,

**WHEREAS**, in planning development and implementation, the lessons of the past should be a major consideration,

**WHEREAS**, the future of the Mindanaoans depends not only on the development of the region's physical and natural resources, but most especially, on a healthy human resource which should be shaped by a holistic education, characterized by high moral values and ethical standards, surrounded by an ecologically balanced environment,

**WHEREAS**, the culture of science and technology should be ingrained in the consciousness of every citizen, and therefore, must be vigorously pursued at all levels,

**WHEREAS**, science and technology are vital in the planning and implementation of development programs for Mindanao,

**BE IT RESOLVED**, as it is hereby resolved, that:

- The principle of **UNITY AND DIVERSITY** in all developmental efforts and endeavors in Mindanao be advocated and adhered to;
- A Human Resource Development Program that has all the components of quality education characterized by high moral values and ethical standards, responsive to the needs of the Region and supportive of the business environment, based on pro-active participation of all concerned be formulated and implemented;
- All developmental plans be based on Mindanao's carrying capacity in terms of present and projected population and the proper utilization of resources;
- The health problems in Mindanao both at the individual and community levels be addressed;
- The science culture be fostered in both formal and nonformal education and nurtured as a way of life;

- A vigorous transfer of technology appropriate to Mindanao be undertaken; and
- Relevant S & T programs tempered by a conscious effort to maintain the ecological balance in the environment be continuously pursued.

FURTHER RESOLVED that these resolutions be presented and adopted by the participants of the 18<sup>th</sup> Annual Scientific Meeting of the Academy, and

FINALLY, RESOLVED that copies of the approved resolutions be submitted to the President, Cabinet Secretaries, Office of the Presidential Assistant for Mindanao, local government units, state colleges and universities, and NGOs in Mindanao for consideration.

Presented to:

The participants of the 18th Annual Scientific Meeting this 11th day of July 1996 at the Insular Century Hotel, Davao City

By:

**THE ASM RESOLUTION COMMITTEE**

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Acad. Salcedo L. Eduardo  
Acad. Edgardo D. Gomez  
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Philippine Science High School Mindanao  
Prof. Perla E. Funa (Region 11)  
Regional Science Teaching Center  
Ateneo de Davao

## **TECHNICAL PAPERS**

### ***AGRICULTURAL SCIENCES DIVISION***

#### **RESEARCH (R&D) AGENDA OF U.P. MINDANAO**

**ROGELIO V. CUYNO**

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Buhangin, 8000 Davao City*

#### ***ABSTRACT***

Research in U.P. Mindanao shall address the agricultural and natural resources system as a whole – the planning, production, harvesting, post-harvest processing, distribution, and marketing instead of the traditional approach of studying the elements and processes separately. Further, the R&D agenda should be guided by the philosophy of prudent and developmental use of natural resources and sustainable management of the environment.

#### **DEVELOPMENT, SELECTION, AND ADOPTION OF LATE BLIGHT RESISTANT POTATO VARIETIES IN THE PHILIPPINE HIGHLANDS**

**ZENAIDA N. GANGA**

*Benguet State University  
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#### ***ABSTRACT***

Late blight caused by *Phytophthora infestans* is the most devastating foliage disease of potato in the world including the traditional growing areas in the Philippines. Farmers spend as much as 12% to 25% of their total production cost to



fungicide alone; spraying 10-15 times in a 60- to 90-day growing period. During the rainy season, a more intensive fungicide spraying (as close as 2- to 3-day intervals) is generally practiced by farmers on susceptible varieties. The use of resistant varieties is still the cheapest and safest means of control.

Evaluation of potato germplasm for resistance to late blight started in 1982 using materials mostly from the International Potato Center (CIP). On-farm screening trials were conducted with the farmers' active participation during selection, resulting in recommendation of two varieties officially released in 1985. Three cycles of recurrent selection resulted in another from CIP in 1995. The advantages of using the recommended late blight resistant varieties compared to using the susceptible Granola, which is the most popular variety, are presented.

The different on-going activities to promote and increase farmers' adoption of the late blight resistant varieties are also discussed.

## **STRATEGIES TO DELAY SENESCENCE IN PERISHABLE CROPS**

**MA. CONCEPCION C. LIZADA**

*Postharvest Horticulture Training and Research Center*

*University of the Philippines Los Baños*

*College, 4031 Laguna*

### **ABSTRACT**

Ripening in fruits, chlorophyll and protein degradation in leafy tissues, as well as fading and petal abscission in flowers are senescent processes which can be inhibited to extend the marketable life of high value crops. Approaches involve the inhibition of ethylene production, the use of ethylene antagonists, and the inhibition of ethylene-mediated processes.

Studies on the extension of postharvest life of durian, mango, papaya, broccoli, and orchids are presented. Strategies involve the manipulation of harvest maturity, use of modified atmosphere storage, reduction of ethylene below threshold levels with the use of an adsorbent, and application of an ethylene antagonist, norbornadiene. Commercial implications are discussed.

## ***BIOLOGICAL SCIENCES DIVISION***

### **CHEMICAL PROTECTION FROM RADIATION-INDUCED GASTROINTESTINAL SYNDROME USING RADIOPROTECTORS FROM HERBAL SOURCES, GC-2112 AND GX-2137**

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#### **ABSTRACT**

A wide range of clinical manifestations of tissue morbidities belonging to the Acute Radiation Complex (ARC) are the major limiting factors which radiation oncologists are primarily concerned with during clinical radio therapy of tumors. Among such critical events is the development of the gastrointestinal (GI) syndrome correlated to the degeneration of the intestinal mucosa following irradiation at absorbed doses of least 15-20 Gy. The possibility of using herbal products, GX-2137 from ginseng (*Panax* sp.), and GC-2112 from garlic (*Allium sativum*), in conferring protection of the duodenum was investigated. The post-irradiation response kinetics of critical tissue parameters (length of villi, number of crypts and villi cells) are analyzed in ICR mice exposed to  $\gamma$ -radiation at absorbed doses: 1.5, 5, 20, 5 Gy using *in situ* microcolony survival and apoptosis assays. Individual crypts reveal time-dependent, differential modalities of radiation death governed by a single-hit target inactivation at 2 h and a multi-hit, multi-target-inactivation phenomenon at

48 h post-irradiation. The behaviors of cryptogenic survival are altered by GC-2112 which are apparent from the increased total crypt cell count at 2 h and the extension of the shoulder region of the biphasic survival curve after 48 h. In addition, a general reduction in apoptotic indices is shown in GC-212-protected duodenum by shifting the single-hit target survival curve, characteristic of apoptotic induction phenomena, to a multi-hit, target-inactivation scheme. Using the linear quadratic (LQ) biomechanistic analysis, utilized in tumor-radioresponse modeling studies, to determine possible mechanisms of action by GC-2112, results suggest that this herbal product protects the crypt cells from apoptotic and clonogenic deaths by preventing  $\beta$ -lethality marked by a decrease in the amount of accumulated radiation-induced sublethal damages without altering intrinsic radiosensitivities of the crypts. In contrast, radioprotection by GX-2137 was not detected. On the other hand, damage to the villi structures, a more radioresistant parameter, is significantly minimized using both radioprotectors at the given radiation doses.

## CARBONIC ANHYDRASE: ITS PHYSIOLOGICAL AND EVOLUTIONARY SIGNIFICANCE IN THE MARINE SYMBIONT *Prochloron*

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### ABSTRACT

The activity of carbonic anhydrase (CA), a photosynthetic enzyme catalyzing the reversible interconversion of  $\text{HCO}_3^-$  to  $\text{CO}_2$ , was studied in *Prochloron*. Measurements revealed that this prokaryotic microalgal symbiont of tropical ascidians exhibits CA activity largely associated with the cell surface. Similar to some chlorophytes, the predominance of extracellular CA and its inhibition increased the  $K_{1/2}$  ( $\text{NaHCO}_3$ ) for photosynthesis suggesting that extracellular CA in *Prochloron* is important in facilitating the supply of  $\text{CO}_2$  into the cell from  $\text{HCO}_3^-$  which is the form common at high pH values, such as in seawater.

Examination of the effect of sulfonamide inhibitors, acetazolamide and ethoxzolamide, revealed that CA activity of *Prochloron* is inhibited with  $I_{50}$  values of 700  $\mu\text{M}$  and 300  $\mu\text{M}$ , respectively. These  $I_{50}$  values bear close resemblance to the measured  $I_{50}$  values for unicellular cyanobacteria and chloroplasts of green algae and higher plants. Since *Prochloron* shares characters with both cyanobacteria and green chloroplasts, it could then be placed as the possible evolutionary link between the cyanobacteria and chlorophytes.

### INTRODUCTION

The genus *Prochloron* consists of marine unicellular algae found in symbiotic association with certain tropical didemnid ascidians. They occur in intimate but extracellular association with the ascidian host colony, either attached to the outer surface, embedded in the test or lying in the common cloacal cavity<sup>12</sup>. Earlier studies showed that they are prokaryotic, with an ultrastructure resembling that of cyanobacteria or blue-green algae<sup>26</sup>. However, they apparently lack the distinctive photosynthetic pigments, phycobilins, of the cyanobacteria, contain both chlorophylls a and b, and have paired or stacked thylakoids like those of eukaryotic chlorophytes or green algae<sup>27</sup>. Their discovery has generated considerable

excitement in the scientific community due to its bearing on theories of the origin of eukaryotic chloroplasts, and has prompted much speculation with regard to their unique position in algal phylogeny.

Measurements of photosynthesis revealed the operation of the  $C_3$  photosynthetic pathway in *Prochloron* with 3-phosphoglycerate as the first carbon fixation product<sup>2</sup> and ribulose 1,5-bisphosphate carboxylase/oxygenase (RuBisCO) as the primary carboxylation enzyme<sup>8</sup>. Since  $CO_2$  is the primary substrate for carboxylation by RuBisCO, and not  $HCO_3^-$ , the commonest form of inorganic carbon in seawater, the enzyme carbonic anhydrase (CA) which catalyzes the conversion of  $HCO_3^-$  to  $CO_2$ , was previously assumed to be present in these organisms<sup>3</sup>.

In this paper, the actual presence of carbonic anhydrase in *Prochloron* will be shown and the physiological and evolutionary significance of this enzyme in this particular microalga will be analyzed.

## MATERIALS AND METHODS

### Collection of ascidian colony and isolation of *Prochloron* cells

Colonies of the ascidian host, *Lissoclinum bistratum* growing on patches of benthic macrophytes and on the leaves of seagrasses or *L. patella* growing on the upper surfaces of coral rubble were collected at Palau, West Caroline Islands. The animal colonies, usually found 1-3 m below surface water, were taken and promptly transported in seawater to the laboratory aboard the Japanese research vessel Sohgen-Maru. Individual colonies were cleaned of contaminants and the algal cells isolated from the host by squeezing gently by hand. The algae were then received in seawater buffered with 40 mM Tris at pH 8.4 and concentrated by centrifugation at about 60 x g for 120 sec.

### Measurement of carbonic anhydrase activity

For the assay of CA activity, the algae isolated from the host were suspended in 20 mM Veronal- $H_2SO_4$  buffer pH 8.3. The enzyme activity on the cell surface (extracellular activity) was assayed directly on such suspensions whereas total activity was assayed in homogenates disrupted by sonication. The difference between the total and extracellular activities represents the intracellular activity. When the effects of CA inhibitors, acetazolamide (AZA) and ethoxzolamide (EZA) were examined, small volumes of the compounds were added to the assay buffer prior to addition of the sample, to provide the appropriate final concentration. The assay method and expression of CA activity were the same as described previously<sup>14</sup> the enzyme activity units expressed on a chlorophyll basis. The concentration of chlorophyll extracted with methanol was determined according to Mackinney<sup>28</sup>.

### Determination of photosynthetic oxygen evolution

Cells collected by centrifugation were washed twice and suspended in freshly prepared CO<sub>2</sub>-free seawater buffered with 40 mM Tris at pH 8.4. The cell suspension (5 mL) at a density of 10 mg chlorophyll per liter was placed in a water-jacketed cylinder equipped with a Clark-type oxygen probe. This was illuminated from one side by a projector lamp at the desired photon flux density of 250 μmol m<sup>-2</sup> sec<sup>-1</sup>. The temperature was kept at 30°C by water running through the water jacket and a thermostat. Initially, the algal suspension was preilluminated until the endogenous carbon source was depleted as measured by cessation of oxygen evolution. The photosynthetic reaction was then started by injecting known amounts of NaHCO<sub>3</sub> solution through narrow hole in the cap of the reaction vessel. Change of oxygen concentrations in the algal suspension was monitored with a recorder connected to the oxygen probe.

### Detection of CA with antiserum

For the detection of CA protein with antiserum, electrophoresis of soluble protein extracts was first carried out on 12.5% (w/v) polyacrylamide gel according to Laemmli<sup>24</sup> and electrotransferred to polyvinylidene difluoride filter (Bio-Rad, Richmond, Calif., USA)<sup>43</sup>. The electrotransferred proteins in the filter blot were then probed with antiserum against extracellular CA of *Chlamydomonas*<sup>15</sup> and spinach chloroplastic CA. Bound CA antibodies in the filter were detected with goat anti-rabbit IgG conjugated horseradish peroxidase acting upon 3,3'-diaminobenzidine tetrahydrochloride<sup>13</sup>.

## RESULTS

Measurement of CA activity of *Prochloron* isolated from *Lissoclinum bistratum* and *L. patella* showed that both species exhibited activity majority (90%) of which is located on the cell surface, and only about 10% of the total CA activity is located intracellularly (Table 1). The possibility that this extracellular CA activity may be attributed to the ascidian host can be excluded since contamination by the host tissue in the cell preparation is negligible and measurement of CA activity in the animal tissue after removal of the algal cells did not show any activity.

To determine the characteristic features of CA in this microalga, the effects of the two most widely used potent sulfonamide CA inhibitors, acetazolamide (AZA) and ethoxzolamide (EZA), on CA activity of intact cells of *Prochloron* isolated from *L. patella* were examined. Sulfonamides were chosen since they were long recognized as specific high-affinity inhibitors of CA from a variety of sources<sup>30</sup>. The measured *I*<sub>50</sub> values, which are the concentrations of the inhibitors required to cause 50% inhibition of activity, for the inhibition by AZA and EZA of extracellular CA from *Prochloron*, are 700 μM and 300 μM, respectively<sup>16</sup>.

Table 1. Carbonic anhydrase activity of *Prochloron* cells isolated from their ascidian host

Ascidian host	CA Activity ( $U \cdot mg\ chl^{-1}$ )		
	Extracellular	Intracellular	Total
<i>Lissoclinum bistratum</i>	6.21	0.56	6.77
<i>Lissoclinum patella</i>	5.35	0.57	5.92

The effect of this acetazolamide concentration on the rate of photosynthetic oxygen evolution of *Prochloron* at varying  $NaHCO_3$  concentrations was then studied. At the optimum photon flux density of  $250\ \mu mol\ m^{-2}\ sec^{-1}$ , addition of  $700\ \mu M$  AZA lowered the rates of photosynthesis under low  $NaHCO_3$  concentrations, while it did not significantly affect the rates under saturating  $NaHCO_3$  concentrations, (Fig. 1). As a consequence, the apparent affinity for inorganic carbon at low  $NaHCO_3$  concentrations, measured as  $K_{1/2}$  ( $NaHCO_3$ ), at pH 8.4 increased from  $160\ \mu M$   $230\ \mu M$  by acetazolamide addition. Since AZA is a membrane-impermeable sulfonamide<sup>35</sup>, this result indicates that CA located on the cell surface of *Prochloron* increased the affinity for  $CO_2$  in photosynthesis at low inorganic carbon concentration.

Comparisons of the measured  $I_{50}$  values for inhibition of *Prochloron* CA by AZA and EZA with published data of CA from a variety of sources are shown in Table 2. It can be observed that the  $I_{50}$  values for *Prochloron* are very high compared to those measured for human red cell isozymes<sup>31</sup>, the extracellular CA of unicellular chlorophyte *Chlamydomonas*<sup>9</sup>, and the intracellular CAs of the unicellular rhodophyte *Porphyridium*<sup>51</sup> and filamentous cyanobacterium *Anabaena*<sup>53</sup>. On the other hand, the unicellular cyanobacterium *Synechococcus*<sup>6</sup> exhibits an  $I_{50}$  value for EZA inhibition similar to *Prochloron*. Likewise, *Prochloron* CA is similar to higher plant CA, such as spinach CA<sup>10</sup> and pea CA<sup>4</sup>, and the intracellular CA of *Chlamydomonas*<sup>21</sup> in terms of sulfonamide inhibition.

To determine whether *Prochloron* CA is immunologically related to higher plant CA, like spinach CA, and not to *Chlamydomonas* extracellular CA as suggested from the sulfonamide inhibition results, immunoblot analysis was carried out using antisera against these two CAs (Fig. 2). The anti-extracellular CA antibody reacted with the 37 kilodalton (kDa) CA monomer in the soluble protein extracts from *Chlamydomonas*. It did not, however, cross-react with soluble protein extracts from spinach or *Prochloron*, thus confirming the inhibition results. Similarly, the anti-spinach CA antibody did not cross-react with *Chlamydomonas* CA. With *Prochloron*, however, a single immunosignal of approximately 34 kDa was observed with anti-spinach CA antibody. Since *Prochloron* CA and spinach CA exhibit almost the same sensitivity to sulfonamide, the 34 kDa band which is antigenically similar to spinach CA might be the *Prochloron* CA. This result, however, should

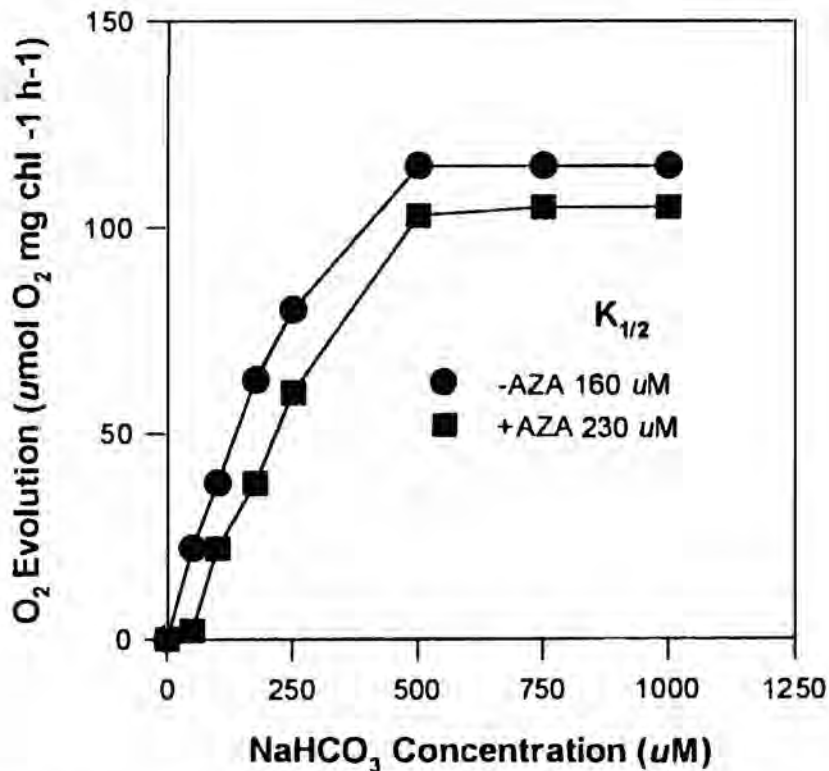


Figure 1. Effect of CA inhibitor acetazolamide on the photosynthetic rates of *Prochloron* at varying concentrations of  $\text{NaHCO}_3$ . Rate of oxygen evolution determined in the absence (●) and presence (■) of 700  $\mu\text{M}$  acetazolamide.

be taken with caution since, aside from the major 26 kDa band which corresponds to the spinach CA monomer, the antibody also reacted with other proteins in the extracts, indicating the low specificity of the antiserum used.

## DISCUSSION OF RESULTS

Previous reports have shown that microalgae have CA localized either on the cell surface and/or inside the cells<sup>1, 32, 46</sup>. Among these microalgae, most chlorophytes exhibit CA activity which is predominantly associated with the cell surface<sup>1</sup>. In cyanobacteria, CA activity is localized inside the cells and no extracellular CA activity has been reported to date<sup>6, 25, 53</sup>. *Prochloron*, although a prokaryote, differs then from the cyanobacterial group, and bears close resemblance to chlorophytes, in exhibiting CA activity predominantly on the cell surface (Table 1).

With regards to the role of this extracellular CA in *Prochloron*, acetazolamide addition caused a decrease in the efficiency with which external inorganic carbon is used for photosynthesis (Fig. 1). This result is consistent with the suggested role of CA in various microalgae, that is, extracellular CA which is located either in the periplasmic space or attached to the cell wall<sup>23</sup> functions in increasing the efficiency



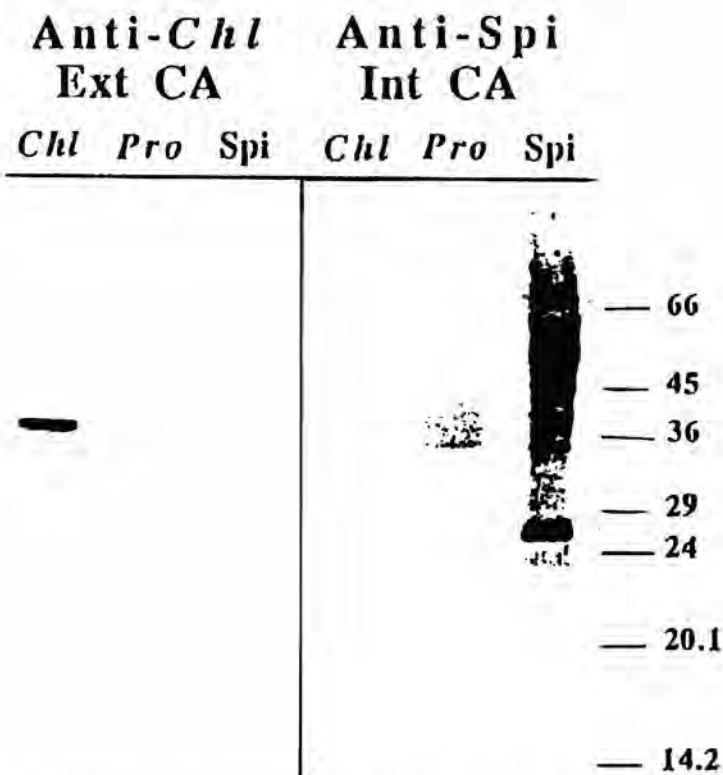


Figure 2. Immunoblots of soluble protein extracts from *Chlamydomonas* (*Chl*), *Prochloron* (*Pro*), and spinach (*Spi*) probed with antibodies against extracellular CA of *Chlamydomonas* (Anti-*Chl* Ext CA) and spinach intracellular CA (Anti-*Spi* Int CA). Molecular weight markers indicated to the right in the figure are in kilodaltons.

with which cells can access external inorganic carbon<sup>7, 41</sup>. This involves facilitating the supply of  $\text{CO}_2$  into the cell from  $\text{HCO}_3^-$  which is the form predominant at high pH values<sup>32, 43</sup>. Thus, with the aid of extracellular CA, *Prochloron* cells have access to the large  $\text{HCO}_3^-$  pool at alkaline pH values in seawater via indirect acquisition of  $\text{HCO}_3^-$ . As to the role of intracellular CA, it is thought to be involved in increasing the steady-state flux of  $\text{CO}_2$  within the cell thereby enhancing the supply of  $\text{CO}_2$  to RuBisCO<sup>5, 22, 44</sup>.

Though CA in both *Synechococcus* and *Anabaena* is assumed to be localized within the RuBisCO-containing carboxysomes<sup>6</sup>, these two cyanobacteria exhibit highly different  $I_{50}$  values in terms of CA inhibition by sulfonamides; the former is less sensitive than the latter (Table 2). It is interesting to note that on the basis of 16S ribosomal RNA sequence data, these species are two of the most highly divergent cyanobacteria known<sup>17</sup>. Since inhibitors like sulfonamides are thought to bind near the active site of the enzyme<sup>31</sup>, the difference in sensitivity to sulfonamides may reflect differences at or near the active site of these enzymes. Another microalga whose CA activity is sensitive to sulfonamide, the rhodophyte

Table 2. Comparison of  $I_{50}$  values for acetazolamide and ethoxzolamide inhibition of carbonic anhydrase from *Prochloron*, human erythrocytes, spinach, pea, and various microalgal species.

Enzyme and source	$I_{50}$ ( $\mu\text{M}$ )		Reference
	Acetazolamide	Ethoxzolamide	
Human Erythrocyte CA I	0.2	0.002	31
Human Erythrocyte CA II	0.01	0.002	31
<i>Chlamydomonas</i> Extracellular CA	0.002	0.005	9
<i>Chlamydomonas</i> Intracellular CA	300	20	21
Spinach CA	100	1	10
Pea CA	450	5	4
<i>Prochloron</i> CA	700	300	16
<i>Synechococcus</i> CA	-	50	6
<i>Anabaena</i> CA	0.3	0.003	53
<i>Porphyridium</i> CA	0.09	0.1	51

*Porphyridium* has CA localized mainly in the chloroplast<sup>52</sup>. CAs from higher plants, on the other hand, are generally considered to be relatively resistant to sulfonamides. Although there is evidence that cytoplasmic isozymes of CA are present in leaves of some plants, the majority of leaf CA activity in spinach is localized in the chloroplast<sup>45, 50</sup> specifically in the stroma<sup>37</sup>. The presence of transit peptide in cDNA coding for pea CA suggests that CA activity in pea also resides within the chloroplast<sup>29</sup>. With regards to the sulfonamide-resistant intracellular CA of *Chlamydomonas*, although a cytoplasmic form of enzyme exists, it was suggested that the observed  $I_{50}$  values probably correspond to the form of CA within the chloroplast<sup>21</sup>. Using immunological techniques, a 45 kilodalton polypeptide immunoreactive with the antispinach CA antiserum was detected in the chloroplast stromal fraction<sup>21</sup>. Recently, there was a report that CA associated with the chloroplast in *Chlamydomonas* is insoluble, suggesting that it is membrane-bound<sup>40</sup>. In another green alga, *Chlorella*, an insoluble membrane-bound CA which is associated with the chloroplast membranes was reported<sup>38</sup>.

Since *Prochloron* exhibits appressed thylakoid membranes containing chlorophylls *a* and *b* characteristic of the chloroplasts of green algae and higher plants, some workers in the field of endosymbiosis favor the idea that the green algal chloroplasts may have arisen by the uptake of *Prochloron* as symbionts<sup>49</sup>. Comparison of the sequences of *psbA* genes, which encode the photosystem II thylakoid protein D1, from a related free-living, filamentous prochlorophyte, *Prochlorothrix*, with those reported for cyanobacteria, a green alga, a liverwort, and several higher plants places the prochlorophytes closer also to green plant chloroplasts than cyanobacteria<sup>33</sup>. On the other hand, sequence comparison of the genes encoding the 16S ribosomal RNA<sup>39, 47</sup>, the large and small subunits of

RuBisCO<sup>34</sup> and a subunit of DNA-dependent RNA polymerase<sup>36</sup> places the prochlorophytes more closely related to cyanobacteria than to the green plastid lineage. Recently, on the basis of 16S ribosomal RNA data, it was suggested that prochlorophytes are polyphyletic within the cyanobacterial radiation, and not specifically related to chloroplasts<sup>48</sup>.

The results presented in this paper showed that in terms of CA inhibition by sulfonamide, *Prochloron* is similar to both the unicellular cyanobacteria and to chloroplasts of green algae and higher plants. On this aspect, then *Prochloron* shares characters with both cyanobacteria and green chloroplasts, suggesting a possible link between the cyanobacteria and chlorophytes. Since sulfonamide inhibition of CA is attributed to its binding with the active site of the enzyme, it may be that the structures of active sites in CAs from *Prochloron*, *Synechococcus*, and chloroplasts of *Chlamydomonas*, spinach, and pea are quite similar to each other. When Western blot analysis was carried out to determine whether soluble protein extracts of *Prochloron* cross-react with anti-spinach CA antibody, a single immunosignal of approximately 34 kDa was observed (Fig. 2). However, concluding that this was *Prochloron* CA would be difficult since the antibody also reacted with some other proteins in the spinach soluble extracts.

At present, cDNAs coding for the spinach chloroplastic CA<sup>11</sup>, pea chloroplastic CA<sup>29</sup> and *Chlamydomonas* extracellular CAs<sup>18</sup> have been isolated and characterized. No significant sequence similarity has been observed between these CAs<sup>19</sup>. More recently, a putative CA gene showing significant sequence similarity to spinach and pea chloroplastic CA but not to *Chlamydomonas* extracellular CA has been identified in *Synechococcus*<sup>20</sup>. Spinach CA and pea CA in the same paper were then suggested to be prokaryotic in nature whereas the *Chlamydomonas* extracellular CA, which shares sequence similarity with mammalian CAs (see also 18, 19) was suggested to be a eukaryotic type. Since *Prochloron* CA exhibits  $I_{50}$  values similar to spinach CA and *Synechococcus* CA but highly different from *Chlamydomonas* extracellular CA or mammalian CA, it would be of interest to determine whether *Prochloron* CA exhibits sequence similarity with the prokaryote-type CAs

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**DNA SYSTEMATICS OF SIMAROUBACEAE  
*sensu lato*: PHYLOGENETIC AND  
TAXONOMIC IMPLICATIONS BASED  
ON THE CHLOROPLAST GENE *rbcL***

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**ABSTRACT**

Phylogenetic analyses of nucleotide sequence data for the chloroplast gene *rbcL* of representatives of all subfamilies indicate that the tropical plant family Simaroubaceae is, in any sense, polyphyletic. The family represents six separate evolutionary lineages, only three of which (Simarouboideae, *Harrisonia*, and Kirkioideae) belong in the Order Sapindales. The family is monophyletic only when composed of members of the subfamily Simaroubaceae plus Leitneriaceae, but excluding *Harrisonia*. Simaroubaceae in this strict sense belongs in a well-defined affinity group including Rutaceae, Cneoraceae, and Meliaceae, while *Harrisonia* has affinities with *Cneorum* and Rutaceae; all these members are characterized by the accumulation of triterpenoids. Kirkioideae occupies a basal position in the Sapindales within a weakly-defined clade including Anacardiaceae and Burseraceae. The other three lineages show affinities with taxa distant from Sapindales: *Irvingia* with a group of rosid I taxa (*sensu* Chase et al.) comprising in part members of Linales and Malphigiales; Surianoideae, including *Stylobasium*, forms a monophyletic group showing affinities with Polygalaceae and Leguminosae; *Picramnia* and *Alvaradoa*, cluster together in an isolated position between the broadly comprised groups of rosid I and rosid II. Support for the affinities suggested here is also evident in other data sources such as wood and pericarp anatomy, pollen morphology, and phytochemistry. The elevation of the picramnioid group, comprising *Picramnia* and *Alvaradoa*, to family rank is suggested, and the recognition of the segregate families, Kirkiaceae, Surianaceae (including *Recchia* and *Stylobasium*) and Irvingiaceae, is supported.



## MARICULTURE OF THE SEA URCHIN *Tripneustes gratilla* AS A RESOURCE MANAGEMENT TOOL

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### ABSTRACT

The collapse of the valuable sea urchin *Tripneustes gratilla* fishery in Bolinao, Pangasinan, has led to the formulation of alternative and multi-faceted approaches to sea urchin management which integrate scientific research and the active participation of local communities. In laboratory culture, the duration of sea urchin larval development ranged from 35-50 days after fertilization. Newly settled juveniles were reared in aquaria for 2-4 months until juveniles were about 1.5 cm test diameter (TD) in size. Thereafter they were transferred to sea pens maintained by local fishers. Juveniles grew rapidly at about 1.4 cm mo<sup>-1</sup> and majority attained the minimum size of sexual maturity of 5-6 cm TC, only 7-8 months after artificial fertilization in the laboratory. Community-managed reproductive reserves in the form of sea pens or cages where juvenile sea urchins can be grown and selectively harvested (i.e., >7.0 cm TD) is an integral and viable part of the management strategy for the recovery of this valuable resource. The utility of this approach as a management tool is reviewed with respect to economic, ecological, and educational values based on the results of various field and laboratory studies and fishers' experiences. The adaptability of this approach, implications of the need for limited rights of exclusive use (e.g., sea pens/ cages) in a traditionally open access fishery, and the development of a local marketing system that would ensure equitable monetary returns to fishers in managing similar invertebrate resources are discussed.

### INTRODUCTION

The fishery of the sea urchin *Tripneustes gratilla* is a major source of livelihood in many coastal villages in the Philippines. Its roe or gonads are eaten as a delicacy called "uni" in specialty restaurants in the country, and is a high-value export product to Japan, Korea, and Taiwan. Moreover, it is also a regular part of the diet of many local coastal communities (e.g., Northern Luzon). In recent years,

overexploitation has precipitated in the collapse of sea urchin fisheries in many areas nationwide. In Bolinao, Pangasinan, the commercial fishery for *T. gratilla* generated multimillion peso earnings per annum, and provided the major source of income for most coastal families prior to the collapse of the fishery in 1992. On January 1993, the local government issued an ordinance banning the commercial harvesting of sea urchins for one year to allow natural populations to recover. Three years after, despite the extended moratorium on commercial harvesting, natural recruitment of *T. gratilla* in the area became very weak. The once dominant invertebrate species on the reef flats of Bolinao is presently practically depleted.

The collapse of the *T. gratilla* fishery in Bolinao, led to the formulation of an alternative and multi-faceted approach to sea urchin management which integrates scientific research and the active participation of local communities. Community-managed sea pen culture which serves as mini-reproductive reserves and a supplemental source of livelihood is the centerpiece of this conceptual model for sea urchin management. Because of the poor natural recruitment of sea urchin populations in the area, the potentials of this management scheme can only be realized through the development of mass culture techniques for the artificial production of sea urchin seedstock. This presentation will describe the experimental and prototype mass culture set-up for larvae and the pilot grow-out culture of juveniles being developed at the UPMSI Bolinao Marine Laboratory. Some results of ongoing studies to enhance the growth and survivorship of cultured sea urchins at various stages of its development will be discussed.

### LARVAL CULTURE AND DEVELOPMENT

In 1994, the entire life cycle of *T. gratilla* was completed under laboratory conditions at the Bolinao Marine Laboratory. Despite many previous attempts, this was the first time that the culture of sea urchin larvae and juveniles was successfully undertaken in the country. Moreover, F3 generations of laboratory cultured sea urchins are being used as broodstock in ongoing culture studies.

Cleavage is completed in 6-9 hours after artificial fertilization of the eggs. The prepluteus stage takes about two days, while the 2-arm, 4-arm, and 6-arm stages lasted about three, seven, and fifteen days respectively. The duration of the 8-arm stage is the most variable, ranging from fifteen to thirty days. On the average, the total larval duration ranged from 42-52 days. Moreover, high variability in the development rates was observed among individuals from the same batch of larvae as well as among larvae from different batches.

### LARVAL SETTLEMENT AND JUVENILE GROWTH

Factors that may enhance settlement and metamorphosis of larvae are being investigated. Experiments on the effect of various primary films such as pure and disinfected cultures of the benthic diatom *Navicula ramossissima* and field-derived

films were conducted. Preliminary results indicate that substrates with field-derived films were the most effective inducers of settlement and metamorphosis. However, diatom-coated plates should also be provided to serve as a food source for the newly metamorphosed juveniles. Likewise, the effect of culture water conditioned with conspecific adults, a sympatric sea urchin species (*Salmacis sphaeroides*) and the brown alga *Sargassum* which is the major diet of juveniles and adults, is being investigated. Preliminary results indicate that the highest percentage of larvae that completely metamorphosed within the first six hours of the settlement assay occurred in *Tripneustes*-conditioned water. This result supports the hypothesis that the presence of conspecific adults is a settlement cue for larvae in the field. As such, the presence of conspecific adults should enhance the local recruitment of *T. gratilla* larvae.

Newly settled juveniles attained a size of about 1 cm test diameter (TD) after two to four months. Growth and survival rates of replicate groups of five batches of cultured sea urchins were monitored in laboratory tanks and in experimental sea cages at two sites in Bolinao (Lucero and Dewey). Results showed that growth and survival rates varied significantly with respect to rearing location and batch of sea urchins. In general, growth and survivorship were significantly higher for all batches of sea urchins reared in sea cages in Lucero and in laboratory tanks when compared to those reared in Dewey. Growth rates were highest during the first three months of the grow-out period prior to the attainment of sexual maturity. In Lucero and the laboratory, average monthly growth rates during this period ranged from 1.3-2.6 cm TD. Notably, majority of the juveniles in the grow-out experiments attained sexual maturity at a size of 5.0-6.0 cm TD, only 7-8 months after artificial spawning and fertilization in the laboratory. In contrast, average monthly growth rates ranged from 0.2-0.8 cm TD after attainment of sexual maturity.

### PILOT COMMUNITY-BASED SEA URCHIN GROW-OUT CULTURE

Growing out juveniles to reproductive adults in sea enclosures is viewed as a complementary measure to enhance the recovery of natural stocks in two ways: aggregating conspecific adults increases the probability of successful fertilization in the field and enhances local recruitment of larvae. Laboratory-cultured seedstock (>1.0 cm TD,  $n = 1,200$  juveniles) were provided to a local group of fishers who signified serious interest in undertaking grow-out culture of sea urchins primarily as a mini reproductive reserve. The fishers were responsible for providing the cages (i.e., at least the labor), feeding and maintaining the culture. Similar arrangements are being developed with other local fishers. This effort is being facilitated by an integrated community-based coastal resources management program which focuses on the empowerment of local communities to become effective resource managers and advocates of sustainable utilization of marine resources in Bolinao.

Aside from the apparent ecological and educational values, sea urchin grow-out culture is also a supplemental source of income for artisanal fishers. Local cooperators in Bolinao have agreed to selectively harvest cultured sea urchins which are > 7.0 cm TD to ensure that the urchins have already contributed to natural larval production. The viability of *T. gratilla* grow-out culture as a supplemental livelihood for fishers is very high because of the fast growth rates and early attainment of reproductive maturity of the species, the high local and export market value of sea urchin roe, and the low capital and maintenance cost of sea pens or cages.

Sea urchin grow-out culture can also be undertaken in areas where natural populations are not yet depleted, and natural seedstock are abundant. In this scenario the full potential of grow-out culture as a resource management tool should be emphasized as a means to educate resource users to become responsible partners in ensuring sustainable utilization of marine resources in general. A similar management approach may be used for other exploited benthic invertebrate resources in the country to forestall further depletion of natural stocks.

## THE COMPLEX OF PHILIPPINE *GYNAIKOTHRIPS* SPECIES

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### ABSTRACT

*Gynaikothrips* are medium-sized to large thrips distributed mainly in the Orient with a few species known from the new world. There are six known species of *Gynaikothrips* in the Philippines: *Gynaikothrips uzeli* Zimmermann, *Gynaikothrips luzonensis* Priesner, *Gynaikothrips capitulatus* Reyes, *Gynaikothrips pedanus* Reyes, *Gynaikothrips pontis* Reyes, and *Gynaikothrips xynos* Reyes.

The species of *Gynaikothrips* in the Philippines can be placed into four species groups: (a) *uzeli* group: including *G. uzeli*, (b) *luzonensis* group: including *G. luzonensis*, (c) *pedanus* group: including *G. capitulatus* and *G. pedanus*, and (d) *pontis* group: including *G. pontis* and *G. xynos*. The first three species groups possess adult characters which definitely place them under *Gynaikothrips* while the *pontis* group possess characters that grade from those of adult *Gynaikothrips* and *Gigantothrips*.

### INTRODUCTION

The name *Gynaikothrips* was first introduced by Zimmermann in 1900 as a misstatement for *Mesothrips*. In Zimmermann's Figure 4 (Zimmermann 1990), the caption appeared as *Gynaikothrips uzeli*. In 1911, Karny gave the first diagnosis of genus *Gynaikothrips* (Stannard 1957; Jacot-Guillarmod and Brothers 1986).

*Gynaikothrips* are medium-sized to large thrips distributed mainly in the Orient with a few species known from the new world. Members of most species are associated with various species of *Ficus* where some of them produce leaf galls (Reyes 1994).

*Gynaikothrips* Zimmermann

Type species: *Mesothrips uzeli* Zimmermann, 1900: 12, by monotypy

**Diagnosis:**

**Antennae.** Antennae 8-segmented; intermediate antennal segments slender, moderately long; segment III with 1 sense cone; segment IV with 2 or 3 sense cones.

**Head.** Head elongate, to rectangular, reticulate. Eyes moderately large, close together. Postocular setae minute to developed. Maxillary stylets short to retracted halfway into head capsule or extended level of postocular setae. Mouthcone elongate, broadly rounded.

**Thorax.** Pronotum with sculpture of irregular twisted striae or weak hexagonal reticulations; epimeral sutures complete or incomplete. Praepectal plates absent; mesopraesternum well developed.

**Legs.** Forefemora slender; foretarsi without tooth in both sexes.

**Wings.** Forewings parallel-sided, with duplicated cilia.

**Abdomen.** Pelta triangular to hat-shaped, small to moderate in size, occasionally with 2 additional lateral lobes. Apical abdominal tergites elongate; tergites II-VII each usually with 2 pairs of wing retaining setae. Tube long, often hairy and slightly bowed.

**Key to Philippine Species of *Gynaikothrips* Zimmermann**

- |       |   |                         |
|-------|---|-------------------------|
| 1     | Antennal segments robust; head slightly longer than wide; eyes prolonged ventrally .....  | <i>G. pedanus</i> Reyes |
| 1     | Antennal segments moderately elongate, head longer than wide; eyes not prolonged ventrally .....  | 2                       |
| 2(1') | Abdominal tergites III and IV each with 3 or more pairs of wing retaining setae .....   | 3                       |
| 2     | Abdominal tergites III and IV each with 2 pairs of wing retaining setae .....   | 4                       |
| 3(2)  | Maxillary stylets reaching level of postocular setae, lying close together towards the base of head; B1 setae of abdominal tergite IX short and stout, rounded apically ..... | <i>G. pontis</i> Reyes  |
| 3     | Maxillary stylets short, lying almost parallel to each other at the base of the head; B1 setae of abdominal tergite IX long and slender, almost pointed apically .....        | <i>G. xynos</i> Reyes   |

- 4(2) Posteroangular setae of pronotum reduced; head about 1.2 times as long as wide; maxillary stylets barely retracted into base of head ..... *G. capitulatus* Reyes
- 4' Posteroangular setae of pronotum well developed; head at least 1.5 times as long as wide; maxillary stylets at least about one third as long as head ..... 5
- 5(4') Postocular setae short, about 0.6 times as long as eyes; head widest towards base ..... *G. uzeli* Zimmermann
- 5' Postocular setae about as long as eyes or longer; head slightly constricted towards base ..... *G. luzonensis* Priesner

**UZELI GROUP**

1. *Gynaikothrips uzeli* Zimmermann  
*Mesothrips uzeli* Zimmermann, 1900: 12

**Diagnosis:**

**Antennae.** Antennal segments III slightly longer and more slender than IV; segment III yellow; IV to VI yellow with brown apices; VII brown with pale base; VIII brown.

**Head:** Head rectangular, surface reticulate and with or without small warts. Postocular setae reduced, shorter than length of eyes.

**Thorax:** Pronotal epimeral setae longest among major setae; anteromarginal setae minute.

**Legs.** Legs generally brown, with pale apices.

**Wings.** Forewings pale with duplicated cilia.

**Abdomen.** Pelta triangular. Abdominal tergites II to VII each with two pairs of wing retaining setae. Tube longer than head.

This species is known in Indoensia, Malaysia, Singapore, Vietnam, India, and Laguna, Philippines.

*G. uzeli*, the type species of genus *Gynaikothrips*, are difficult to differentiate from those of *G. ficorum*, which are also common on several species of *Ficus*.

**LUZONENSIS GROUP**

1. *Gynaikothrips luzonensis* Priesner  
*Gynaikothrips luzonensis* Priesner, 1939: 480

**Diagnosis:**

**Antennae.** Antennal segment II longer and more slender than segment IV.

**Head.** Head longer than wide, with four pairs of small median setae. Ocellar hump prominent, eyes large. Postocular setae longer than dorsal length of eyes, with blunt apices.

**Thorax.** Pronotal major setae reduced with knobbed apices; anteromarginal setae minute.

**Legs.** Legs bicolored.

**Wings.** Forewings pale, each with 18-19 duplicated cilia.

**Abdomen.** Pelta triangular. Abdominal tergites II and VII each with two pairs of wing retaining setae. Tube longer than head.

Adults of this species differ from those of *G. uzeli* in the shape of the head and pelta, well-developed postocular setae, and presence of four pairs of small median setae in the head.

*G. luzonensis* is known in Taiwan and in Laguna and Zamboanga, Philippines. They were collected on different species of *Ficus*, *Antidesma*, and *Ricinus communis*.

#### **PEDANUS GROUP**

1. *Gynaikothrips capitulatus* Reyes  
*Gynaikothrips capitulatus* Reyes, 1996: 89.
2. *Gynaikothrips pedanus* Reyes  
*Gynaikothrips penadus* Reyes, 1994: 397.

Members of this species group are characterized by the following features:

#### **Diagnosis:**

**Antennae.** Antennal segments robust to elongate; segment III with 1 inner sense cone; segment IV with 1 inner and 2 outer sense cones

**Head.** Head longer than wide, reticulate. Eyes about a third of head length sometimes prolonged ventrally. Postocular setae developed, shorter than dorsal length of eyes. Maxillary stylets short.

**Thorax.** Pronotal major setae reduced to well developed. Anteromarginal setae vestigial to developed. Epimeral setae prominent.

**Legs.** Legs bicolored; femora brown sometimes with pale apices; foretibiae yellow; mid and hindtibiae brown with pale apices; tarsi yellow; foretarsi without tooth.

**Wings.** Forewings light brown, with 8 to 14 duplicated cilia; subbasal wing setae well-developed, with blunt to knobbed apices; setae S3 longest.

**Abdomen.** Pelta triangular, reticulate; a pair of companiform sensilla present. Abdominal tergites II to VII each with 2 pairs of wing retaining setae. B1 setae of tergite IX shorter than tube, pointed at apex. Tube longer than head.



*G. capitulatus* differ mainly from *G. pedanus* by the shape of their antennal segments and pelta, and in having vestigial anteromarginal setae. This species is known only in Zamboanga, Philippines on an unidentified plant.

Unlike all other described members of the genus, adults of *G. pedanus* species have a short head, stouter body, and more robust antennal segments. As in *G. capitulatus* they possess short maxillary stylets. This species is known in Cagayan, Philippines on rolled leaves of Curran's Lipote.

### **PONTIS GROUP**

1. *Gynaikothrips pontis* Reyes  
*Gynaikothrips pontis* Reyes, 1996: 92
2. *Gynaikothrips xynos* Reyes  
*Gynaikothrips xynos* Reyes, 1996: 94

Members of this species group are characterized by the following features:

#### **Diagnosis:**

**Antennae.** Antennal segments III-VIII elongate; segments I and II brown, II pale basally or apically; III to VIII yellow or brown; III and IV subequal, III with 1 outer sense cone, IV with 1 inner and 1 or 2 outer sense cones.

**Head.** Head rectangular, about 2.0 times as long as wide, widest at base, reticulate with small warts. Eyes large, protruded. Postocular setae reduced to well-developed, with blunt apices. Maxillary stylets short to reaching level of postoculars.

**Thorax.** Pronotal major setae with blunt apices; posteroangular setae reduced to developed; epimeral setae well developed.

**Legs.** Femora shown; tibiae yellow or brown on basal third; tarsi yellow; foretarsi with tooth.

**Wings.** Forewings pale, with dark, median longitudinal stripe and duplicated cilia.

**Abdomen.** Pelta hat-shaped to triangular. Abdominal tergites with strong warty reticulations. Tergite II with 2 pairs of wing retaining setae, those on III to V with 4 pairs, VI to VII 2 pairs. Tube longer than head.

*G. xynos* differs mainly from *G. pontis* in having shorter maxillary stylets lying nearly parallel in the base of head, conspicuous postocellar setae, shorter antennal segment IV with 1 inner and 2 outer sense cones (1 outer sense cone in *G. pontis*), triangular pelta; and long and slender B1 setae on tergite IX. *G. pontis* is known only in Laguna and Mt. Apo, Philippines on leaves of *Ficus pseudopalma*, an unidentified plant, and on sweeping materials. *G. xynos*, on the other hand, is known only in Laguna, Philippines on *Euphorbia hirta* and *Ficus* sp.

*G. pontis* and *G. xynos* resemble *Gigantothrips elegans* Zimmermann, type species of the genus *Gigantothrips* in having longer body and intermediate antennal segments; tergites with additional pairs of wing retaining setae and accessory setae; and presence of foretarsal tooth.

*G. pontis* and *G. xynos* differ from *G. elegans* in having antennal segment III shorter or about as long as segment IV; pronotum with less-developed setae anteriorly and laterally except anteroangulars; abdominal tergites II with 2 pairs of wing retaining setae, III to V with 4 pairs, and VI and VII with 2 pairs. In *G. elegans*, abdominal tergite II with 4 pairs of wing retaining setae, III to VII with 5 or more pairs of such setae.

*Gigantothrips elegans* Zimmermann

Type species: *Gigantothrips elegans* Zimmerman, 1900: 18 by monotypy.

**DIAGNOSIS:** Head elongate, to rectangular, reticulate. Eyes moderately large, closed together. Postocular setae minute to developed. Antennae 8-segmented; intermediate antennal segments slender, moderately long; segment III with 1 sense cone; segment IV with 2 or 3 sense cones. Maxillary stylets retracted into head capsule. Mouthcone elongate, broadly rounded.

Pronotum with sculpture of irregular, twisted striae or weak hexagonal reticulations; epimeral sutures complete or incomplete. Praepectal plates absent; mesopraesternum well developed. Forefemora slender; foretarsi each with small tooth in both sexes. Forewings parallel-sided, with duplicated cilia.

Pelta hat-shaped, moderate in size. Abdominal tergites slender, elongate; tergite II with 4 pairs of wing retaining setae, III-VII each with 5 or more pairs of wing retaining setae. Tube long, with developed setae.

Worldwide, about 21 species are presently included in genus *Gigantothrips* and about 89 species in genus *Gynaikothrips*. Most of these species are known in the tropics and usually associated with various species of *Ficus*.

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**MATHEMATICAL, PHYSICAL, AND  
ENGINEERING SCIENCES DIVISION**

**AN ANTIMICROBIAL TRITERPENE FROM THE  
LEAVES OF *Lantana camara* L.  
(FAM. VERBENACEAE)**

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**ABSTRACT**

*Lantana camara* L. leaves afforded a novel triterpene 22 $\beta$ -acetoyloxylantanic acid (1), 22 $\beta$ -dimethylacryloyloxylantanic acid (2), a mixture of 22 $\beta$ -dimethylacryloyloxylantanic acid (2) and 22 $\beta$ -angeloyloxylantanic acid (3), lantanolic acid (4), and lantic acid (5) by gravity column chromatography (dry packing). The structure of 1 was elucidated by NMR and FT-IR spectroscopy and mass spectrometry, while the structures of 2-5 were elucidated by comparison of their <sup>1</sup>H NMR spectral data with those of 1. Compound 1 was tested for its antimicrobial potential against six microorganisms and was found active against *Staphylococcus aureus* and *Salmonella typhi*. It was also tested for its anti mutagenicity potential by the micronucleus test. Results of the study indicated that it reduced the number of micronucleated polychromatic erythrocytes by 76.7% at a concentration of 6.75 mg/kg mouse.

**KEY WORDS:** *Lantana camara*, Verbenaceae, triterpenes, lantanolic acid, antimicrobial

**INTRODUCTION**

*Lantana camara* L. is a native of tropical America, but now occurs throughout the Philippines in thickets and waste lands at low and medium altitudes [1]. Crushed leaves of *L. camara* are applied as poultice to wounds and injuries, while

the decoction of boiled leaves is used for washing affected areas in cases of dermatitis, eczema, tinea, and furuncles. Antipyretic properties of the leaves are mainly attributed to lantadene A [2]. Previous investigations of *L. camara* afforded triterpenes of the lantadene type [3-6], lantanolic acid [3], lantic acid [4], icterogenin and hederagonic acid [7], camaroside and phenolic compounds [8]. We now report the isolation of a new triterpene (1) and its antimicrobial and antimutagenic properties.

## EXPERIMENTAL

### General Experimental Procedures

NMR spectra were recorded in  $\text{CDCl}_3$  solutions on a Bruker AM 300 NMR spectrometer with  $\text{CDCl}_3$  (7.26, 77.0 ppm) as reference. Eims were carried out on a JEOL D 100 mass spectrometer. Si gel type 60 (Merck) was used for column chromatography and plastic-backed plates coated with Si gel F254 (Merck) for thin layer chromatography. Plates were visualized by spraying with vanillin/ $\text{H}_2\text{SO}_4$  and warming.

### Biological Material

Leaves of the pink-flowered variety of *Lantana camara* were collected from the University of the Philippines Los Baños campus in March 1994.

### Extraction and Isolation

The air-dried leaves (600 g) were soaked in  $\text{CHCl}_3$  (3.6 L) for the three days to afford a crude extract (23 g). The extract (4 g) was chromatographed on a gravity column packed with dry silica gel (70-230 mesh) using increasing proportions of acetone in  $\text{CHCl}_3$  (5% increment) and  $\text{CH}_3\text{OH}$  in acetone (10% increment) as eluents. The 30-50% methanol in acetone fractions were rechromatographed in 7:1.5:1.5 ( $\text{DCM}:\text{Et}_2\text{O}:\text{acetonitrile}$ ) as eluent to afford 1 [colorless crystals, m. pt. 270-273 °C,  $\alpha_D = 87.72$  ( $\text{CHCl}_3$ ), 30 mg]. The 10-20% acetone in  $\text{CHCl}_3$  fractions were rechromatographed in 10%  $\text{CHCl}_3$  to afford 2 [colorless cystals, m. pt. 285-287 °C  $\alpha_D = +115.38$  °C ( $\text{CHCl}_3$ ), 33 mg]. The 25.60% acetone in  $\text{CHCl}_3$  fractions were rechromatographed in 15% acetone in  $\text{CHCl}_3$  to afford 4 (colorless crystals, 21.7 mg) and a mixture of 2 and 3.

### Antimicrobial Test

A microbial suspension containing approximately  $10^7$  cells/mL was prepared for each test organism for 24-hour agar culture using 0.1% peptone water. One-tenth (0.1) mL of the bacterial suspension was transferred into a pre-poured 30 mL deep nutrient agar plate, the yeast suspension into a glucose yeast peptone agar plate, and the fungal suspension on a potato dextrose agar plate. About 5 mL of

the corresponding melted agar cooled to about 45°C was immediately poured into the plate. The plate was swirled to distribute the microbial cells evenly on the plate. After the overlay agar had solidified, three 1-cm diameter holes were cut from equidistant points using a sterile cork borer.

One-tenth (0.1) mL portions of the extract (30 µg/mL) were placed in duplicate holes per organism. Similar volumes of the solvent acetone and of the corresponding antibiotic for each test organism were placed in the remaining two wells on the plate. Plates were incubated at room temperature to prevent evaporation of liquid on the petri lid that may cause interference in distribution of organisms on the surface. Bacterial and yeast plates were read after 24 hours, while the mold plate was read after three days. Clearing zones were measured in millimeters (mm), the average for each supernatant was taken, and the antimicrobial activity index (AI) was computed.

### Antimutagenicity Test

Mitomycin C (2.75 mg/kg mouse) dissolved in H<sub>2</sub>O and **1** (6.75 mg/kg mouse) dissolved in DMSO (7.5 mL/kg mouse) was administered orally and simultaneously to mice of the Swiss strain (source: DOST). For the positive control, only mitomycin C (2.75 mg/kg mouse) and DMSO (7.5 mL/kg mouse) were administered orally to mice. Five mice each were tested for **1** and the positive control. The second administration was conducted after twenty-four hours. Six hours after the second treatment, the mice were sacrificed and blood from the bone marrow was flushed with fetal calf serum. Smears on slides, three per mouse were prepared, and were stained with undiluted May-Gruenwald, followed by 50% May-Gruenwald solution, then 15% Giemsa stain. The number of micronucleated polychromatic erythrocytes (MPCE) per 1,000 polychromatic erythrocytes was counted with the use of a high power microscope and the results are given as % reduction in MPCE.

## RESULTS AND DISCUSSION

The chloroform extract of the air-dried leaves of *L. camara* (pink-flowered variety) afforded a novel triterpene (**1**), 22β-dimethylacryloyloxylantanolic acid (**2**), a mixture of **2** and 22β-angeloyloxylantanolic acid (**3**), lantanolic acid (**4**), and lantic acid (**5**). The structure of **1** was elicited by NMR (<sup>1</sup>H, <sup>13</sup>C, DEPT, COSY) and FT-IR spectroscopy, and mass spectrometry, while the structures of **2-5** were elucidated by comparison of their <sup>1</sup>H NMR spectral data with that of **1**.

The <sup>1</sup>H NMR spectrum of **1** indicated an olefinic H at δ 5.40, a carbonyl H of an ester at δ 4.95, and carbonyl Hs of an ether or alcohol at δ 4.21 and δ 3.90. The ester functionality of **1** is confirmed by the FT-IR absorption band at 1250 cm<sup>-1</sup> and 1720 cm<sup>-1</sup>. The spectrum also indicated seven methyl groups, one of which belongs to an acetate at δ 2.00 (Table 1).

Table 1. Comparison of the  $^1\text{H}$  NMR Spectral Data of 1-4

Chemical Shifts, $\delta$					Functionalities
1	2	3	4	5	
5.39	5.60, 5.39	5.39	5.29	5.29	C=CH
4.95	4.95	4.95			CH-O (ester)
4.21, 3.90	4.21, 3.90	4.21, 3.90	4.21, 3.90	4.21, 3.90	$\text{CH}_2\text{O}$
1.14(s), 1.08 (s), 1.01 (s), 0.95 (2 $\text{CH}_3$ , d), 0.78 (s) 2.00	1.18(s), 1.08(s), 1.04(s), 1.08(s), 0.92(s), 0.79(s)	1.25(s), 1.16(s), 1.04(s), 1.00(s), 0.90(s), 0.80(s)	1.38(s), 1.27(s), 1.05(s), 1.16(s), 0.96(s), 0.73(s)	1.14(s), 1.08(s), 1.01(s), 0.95 (2 $\text{CH}_3$ , d), 0.98(s)	$\text{CH}_2$
	2.15(s,br), 1.88(s,br)				$\text{CH}_3\text{C}=\text{O}$ $\text{CH}_3)_2=\text{C}$
		6.00(m) 1.04(2 $\text{CH}_3$ , d)			C=CH $\text{CH}_3\text{C}=\text{OCH}_3$

Further information was given by the  $^{13}\text{C}$  and DEPT NMR spectra of 1. The spectra indicated the following functionalities: a carbonyl of an ester at 170.2 ppm, a carbonyl of a carboxylic acid at 178.5 ppm ( $\text{IR } \nu_{\text{max}} 3400 \text{ cm}^{-1}$ ), an acetal at 98.9 ppm ( $\text{IR } \nu_{\text{max}} 1020 \text{ cm}^{-1}$ ), an oxygenated methylene C at 67.9 ppm, an oxygenated methine C at 75.7 ppm, a fully substituted olefinic C at 137.2 ppm, a methine olefinic C at 126.1 ppm, eight methylene Cs, and seven methyl Cs (Table 2). Thus, 1 contained thirty-two carbons, forty-eight hydrogens, and six oxygens. This was supported by the mass spectrum which showed a molecular ion peak at 528 (5%) which corresponds to a molecular formula of  $\text{C}_{32}\text{H}_{48}\text{O}_6$ . The peak at  $m/z$  468 (40%)

Table 2. Comparison of  $^{13}\text{C}$  NMR Spectra of 1-2

2	1	Functionalities
178.0	178.5	COOH (acid)
163.4	170.2	C=O (ester)
143.0, 116.0	137.2	C=
157.0, 122.5	126.1	CH=
98.9	98.9	O-C-O
67.7	67.9	$\text{CH}_2\text{-O}$
75.3	75.7	CH-O
	49.3, 42.4, 41.9, 40.2, 39.2	C
	50.2, 49.3, 41.9, 39.2, 32.2	CH
	35.1, 34.9, 31.2, 29.8, 27.9, 24.8, 23.8, 19.6	$\text{CH}_2$
	16.9, 17.7, 18.4, 20.7, 21.2, 23.1, 27.1	$\text{CH}_3$

resulted from the loss of acetic acid, while the peak at  $m/z$  450 (18%) resulted from the loss of acetic acid and  $H_2O$ . From the molecular formula, the index of hydrogen deficiency is nine. With three double bond equivalents (2  $C=O$  and 1  $C=C$ ) deduced from the  $^{13}C$  and DEPT NMR spectra of **1**, the remaining hydrogen deficiency can be attributed to six carbocyclic systems.

The COSY spectrum indicated the following isolated systems: a carbinyl H at  $\delta$  4.95 was coupled to the Hs at  $\delta$  1.47 and  $\delta$  1.79, with the latter coupled to the H at  $\delta$  1.35, which was in turn coupled to the methyl Hs at  $\delta$  0.92 and the H at  $\delta$  1.38, with the latter coupled to the H at  $\delta$  1.52 and the methyl Hs at  $\delta$  0.92; an olefinic H at  $\delta$  5.35 was coupled to the allylic methylene Hs at  $\delta$  1.79 and  $\delta$  2.10, with the latter coupled to the H at  $\delta$  1.23; the H at  $\delta$  2.40 was coupled to the H at  $\delta$  1.78 and the methylene Hs at  $\delta$  1.35 and  $\delta$  0.84; the methylene Hs at  $\delta$  2.14 and  $\delta$  1.70 were coupled to the Hs at  $\delta$  1.18 and  $\delta$  1.52; the H at  $\delta$  1.50 was coupled to the methylene Hs at  $\delta$  1.34 and  $\delta$  1.20 which were in turn coupled to the H at  $\delta$  1.63; the carbinyl Hs at  $\delta$  4.21 and  $\delta$  3.45 were coupled to each other.

Correlation of the partial structures deduced from the COSY spectrum and the data from the  $^1H$ ,  $^{13}C$ , DEPT NMR, FT-IR and MS, as well as comparison with the structures of compounds previously isolated from *L. camara* resulted in structure **1**.

The  $^1H$  NMR spectrum of **2** showed resonances for olefinic Hs at  $\delta$  5.39 and  $\delta$  5.60; carbinyl Hs of an ether or alcohol at  $\delta$  3.90 and  $\delta$  4.21; a carbinyl H of an ester at  $\delta$  4.95; allylic methyl groups at  $\delta$  2.15 and  $\delta$  1.88; and six methyl groups at  $\delta$  1.18;  $\delta$  1.08,  $\delta$  1.04,  $\delta$  0.92 ( $2CH_3$ ), and  $\delta$  0.79 (Table 2). Comparison of the  $^1H$  NMR data of **1** and **2** indicated that the differences between the two compounds are the esters attached to the triterpenes. The ester of **1** is an acetate ( $\delta$  2.0), while that of **2** is a dimethylacrylate ( $\delta$  1.88,  $\delta$  2.15,  $\delta$  5.6).

To support the structure of **2**, the  $^{13}C$  NMR spectra of **1** and **2** were compared (Table 2). The spectrum indicated thirty-five carbons in **2** with the following changes in functionalities: an additional olefin (157.0 and 116.0 ppm), a deshielded carbonyl carbon (165.4 ppm) due to conjugation, and an additional methyl group.

The structure of **3** was deduced by subtracting the resonances of **2** from the  $^{13}C$  NMR spectrum of a mixture of **2** and **3**. The olefin H at  $\delta$  6.00 (m) and the methyl Hs at  $\delta$  1.04 (d) indicated that the ester substituent of **3** is an angelate.

Compounds **2** and **3** have been reported as constituents of *L. camara* with pink flowers, but they have not been purified [9]. This is the first time that **2** was obtained pure and characterized.

The structure of **4** deduced by comparison of its  $^1H$  NMR spectrum with the spectra of **1-3** (Table 1). The resonances for the ester substituents of **1-3** were not found in **4**. In addition, the resonance for the carbinyl H ( $\delta$  4.95) was not found in **4**. Thus, **4**, is the unsubstituted triterpene, lantanolic acid [9].

The structure of **5** was elucidated by comparison of its  $^1H$  NMR spectral data with that of **4** (Table 1). Compounds **1** and **4** have similar spectral data, except for the presence of six methyl singlets in **4**, while **5** has four methyl singlets and two methyl doublets.



Table 3. Antimicrobial Index

<i>Bacterium</i>	<i>I</i>	<i>Chloramphenicol</i>	<i>Tetracycline</i>	<i>Acetone</i>
<i>E. coli</i>	0.2, 0		1.5	
<i>S. aureus</i>	0.7, 1.2	1.5, 1.7		
<i>P. aeruginosa</i>	0.1, 0.2		0.6, 0.5	0.1, 0.2
<i>S. typhi</i>	0.4, 1.0		0.8, 0.8	0.1, 0.2
<i>Fungus</i>		<i>Clotrimazole</i>		
<i>C. albicans</i>	0.2, 0.2	4.0, 3.0		0.2, 0.2
<i>T. mentagrophytes</i>	2.3, 2.3	5.0, 4.0		2.0, 2.1

*L. camara* is known to have antimicrobial properties. Thus, **1** was tested for its antimicrobial potential by the use of the well method. Results of the study are presented in Table 3. Among the six microorganisms tested, **1** was found to be active against *S. aureus* and *S. typhi* with an average antimicrobial index of 0.95 and 0.55, respectively at a concentration of 30  $\mu\text{g/mL}$ .

The antimutagenicity potential of **1** was also tested by the use of the micronucleus test. Results of the study indicated that **1**, at a concentration of 6.75 mg/kg mouse, reduced the number of micronucleated polychromatic erythrocytes induced by Mitomycin C by 76.7%. Statistical analysis using the T-test showed that there is a significant decrease in MPCE at  $\alpha = 0.01$ . Therefore, **1** possesses a high antimutagenic activity.

## CONCLUSION

Our investigation of the chloroform extract of the leaves of pink-flowered *L. camara* thus afforded a new triterpene (**1**), **2**, a mixture of **2** and **3**, **4**, and **5**. Results of the antimicrobial test on **1** indicated that it is active against *S. aureus* and *S. typhi*, while results of the micronucleus test indicated that it has a high antimutagenic activity.

## ACKNOWLEDGMENT

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## THE FEASIBILITY OF USING IPIL-IPIL GUM AS AN ALTERNATIVE TO GUAR GUM

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### ABSTRACT

Currently, most of the excipients used in the pharmaceutical industry are imported. In 1993, the Philippines imported a total of 278,262 kg of guar gum. The estimated gum consumption of the pharmaceutical industry is 156,74 kg/year.

A locally grown plant that can be tapped for gum production is *Leucaena leucocephala* (Lam.) de Wit, locally known as ipil-ipil. The crude gum from the seeds of the plant was purified by fractional precipitation with ethanol followed by ion exchange chromatography using a DEAE-cellulose column. Physicochemical and chemical studies showed that the protein-free gum exhibited properties similar to that of galactomannan from guar gum. A hardness test performed on tablets formulated with the purified gum showed that the gum is an effective binder.

A summary of a pre-feasibility study on the commercialization of ipil-ipil seed gum is discussed.

## **SURFACE SENSITIVE ANALYSIS OF THIN OXIDE FILMS ON SEMICONDUCTORS**

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### **ABSTRACT**

Oxide layers on semiconductor-based electronic devices play an important role in the performance of the device. Thicknesses of about 5 nm are projected for future designs. Common commercial cleaning and etching preparations of the semiconductor materials produce oxide layers with a thickness in this range. The oxidized surface of indium phosphide (InP) was studied. The techniques of Auger Electron Spectroscopy (AES) and Grazing Incidence X-ray Photoelectron Spectroscopy (GIXPS) were employed. These techniques provide a truly surface sensitive analysis of the material. The native oxide on InP was measured to have a thickness of about 2.0 nm. The chemical composition of the layer was also obtained.

### **INTRODUCTION**

Modern electronic equipment and instrumentation make use of an array of a large number of semiconductor devices. Many of these devices are in fact integrated into a smaller electronic component called integrated circuits (ICs) or "chips".

ture shown in Figure 1. The metal serves as the gate to which a voltage is applied: Electrons move from the source to the drain through some channels in the semiconductor material.

A similar structure used extensively as an electronic device is the metal-oxide-semiconductor (MOS). Instead of using an insulator to separate the metal and the semiconductor, an oxide of the semiconductor is grown. This is typical in silicon based field effect transistors (FET). The native oxide  $\text{SiO}_2$  is produced during the preparation of the silicon wafers. Metal contacts are connected onto the oxide.

Another device structure also extensively used is the metal semiconductor junction found in diodes. The metal gate is bonded directly onto the semiconductor. However, under normal atmospheric conditions, oxide growth on both the semiconductor and the metal is not totally eliminated. A negligible amount of the oxide may not hinder usual functions of the device but future degradation and instability in performance is anticipated.

The quest for faster and improved devices led to the search for other semiconductors. Indium phosphide (InP) and gallium arsenide (GaAs) are now used in view of their faster electron mobilities and more efficient photon energy conversion compared to silicon. However, the chemical stability of the phosphorus oxides over the arsenic oxides make InP a better material for MIS/MOS devices while GaAs is preferred for metal semiconductor devices.

The current trend toward smaller device areas and thinner insulating layers is evident in the miniaturization and compactness of new electronic equipment. Oxide layers of the future are expected to have a thickness of about 5 nm ( $1 \text{ nm} = 10^{-9} \text{ m}$ ) compared to present day devices with oxide thicknesses of about  $1 \mu\text{m}$  ( $10^{-6} \text{ m}$ ). It is therefore necessary that a method of sampling thin layers of the oxide and the semiconductor and metallic surfaces be used to determine the chemical species present on the interface. A knowledge of the composition of the interface can give us an insight on the performance of a fabricated device.

There have been diverse tools and applications of surface characterization since the 1970s.<sup>2,3</sup> The volume of papers published on studies of surfaces has grown significantly since then that the field is now widely accepted as surface science.

All surface analyses techniques use a probe to excite the materials and information about their surfaces is obtained by detecting quantities emitted from the surface. Common excitation probes make use of photons, electrons, ions, neutral particles, phonons, or electromagnetic fields. The detected quantities may be particles (photons, electrons, ions, neutral atoms, or phonons) or fields (electric or magnetic).

In this study, two of the most common techniques were employed to study the oxide layer on indium phosphide, namely, Auger Electron Spectroscopy (AES) and Grazing Incidence X-ray Photoemission Spectroscopy (GIXPS). These two techniques are the most advantageous over other methods.<sup>3</sup>

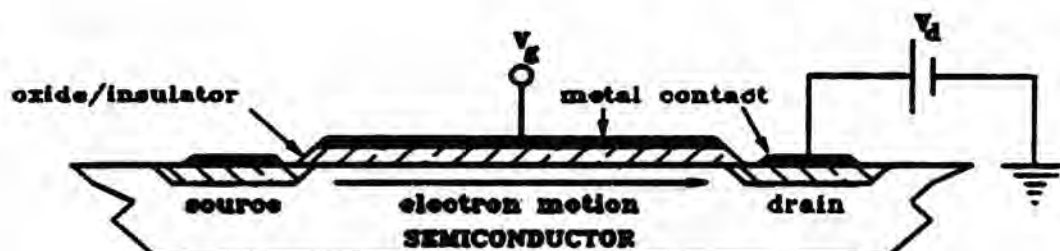


Figure 1. Schematic diagram of a MOS/MIS structure.

### EXPERIMENTAL DESCRIPTION

Surface analyses techniques are carried out in an ultra high vacuum (UHV) environment typically with ultimate pressures of  $10^{-9}$  to  $10^{-10}$  torr. This ensures that the excitation probe will reach the sample without undergoing collisions or interaction with the ambient gas. Likewise, the sample surface will not be subjected to prolonged contamination from the ambient.

The specimen is then bombarded by x-rays for X-ray Photoemission Spectroscopy (XPS) and electrons or x-rays for AES. Electrons are emitted from the sample and are detected and analyzed.

For AES, the specimen is usually bombarded with electrons having energies between 2 and 15 keV. Core level ionizations of the specimen atoms decay by either the emission of characteristic x-ray or the emission of Auger electrons. The Auger process is a two-electron decay process wherein an electron from a higher level in the atom fills the initial core level vacancy and another electron from the same or another level is emitted. The kinetic energy of the emitted electron called the Auger electron is related to the binding energy of the electron in the level which was initially ionized and of the two electrons which participated in the process. Figure 2 shows a schematic diagram of the process of Auger electron emission. The kinetic energies of electrons emitted from the specimen are measured with an electron analyzer which measures the Auger electron distribution. Peaks in this distribution correspond to Auger electrons that leave the specimen without inelastic scattering and with characteristic energies which are used to identify specific atoms.

For XPS, characteristic x-rays from the anode (often Mg or Al) of a relatively simple x-ray tube excite photoelectrons from core levels (when energetically possible) of the specimen. The photoelectrons that emerge from the specimen in a

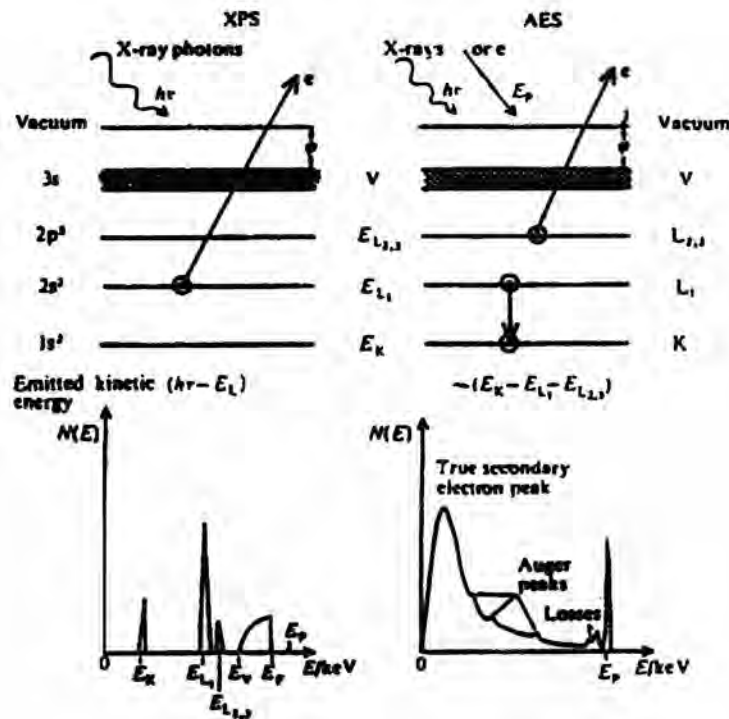


Figure 2. Schematic diagram of X-ray photoemission and Auger electron processes. Energy levels are that of an ideal free one-electron metal (not drawn to scale). The quantities on the left are the electronic configuration. At the right are the labels for orbitals used in X-ray spectroscopy.  $E_K$  is the binding energy measured from the vacuum level. The graphs at the bottom indicate the number  $N(E)$  of electrons with kinetic energies between  $E$  and  $E + dE$  measured in the energy distribution. The horizontal scale corresponds to what is obtained in common practical cases.

particular direction enter an electron energy analyzer (similar as in AES) which measures the photoelectron energy distribution. Peaks in this photoelectron energy distribution correspond to photoelectrons from core levels that emerge without inelastic scattering in the specimen. The kinetic energies of the photoelectrons contributing to these peaks are related to core level binding energies which can be used for elemental identification. The shapes and energies of these peaks also provide information on the chemical states of the sample since the binding energies depend on the chemical environment.

Auger peaks are also observed in XPS where the core level vacancies are created by x-rays. These however cause interference and complicate the spectra. Nonetheless, they provide reference energies and Auger related information. The photoelectron peaks are narrower and simpler than the Auger peaks. The valence spectra are generally very weak in XPS but are dominant in AES. The energies of peaks in both sets of spectra are in the same range. This means that the depth to

which the surface is analyzed is quite similar for both techniques since it is the energy of the ejected electrons that determine the analyzed depth rather than the energy of the excitation beam. The surface sensitivity of both techniques is due to the very short inelastic mean free paths of photoelectrons and Auger electrons (0.2-2.0 nm) in most solids in the energy range of 30-2000 eV normally used. Photoelectrons and Auger electrons emitted deeper in the specimen have a much greater chance of being inelastically scattered than those emitted near the surface. Thus, only the electrons emitted from near the surface will be detected.

Table 1 summarizes the major advantages and limitations of AES and XPS for surface analyses. Both techniques are complementary and may be carried out with the same analyzer in situ. X-ray excitation is used for the reason that it causes the least damage on the sample being analyzed. The use of electron beams for core level ionization are preferred because the electron sources are normally "brighter" than x-ray sources. Electron beams of small diameter may be easily produced to provide better lateral imaging. Since the x-rays are more energetic than the electron beams often used, x-rays have deeper penetration (up to 1  $\mu\text{m}$ ) into the sample than the electron beams. This makes AES a more surface sensitive technique.

Figure 3 shows an experimental apparatus for the GIXPS measurements. The electron energy analyzer is the cylindrical mirror analyzer (CMA) with a built in electron gun in the axis of the CMA for AES. The electron beam is at normal incidence to the sample. However, AES measurements in this study were performed in another UHV chamber. A laboratory Mg  $K_{\alpha}$  x-ray tube was used. It is usually at large angles (relative to the sample plane) of x-ray incidence for the usual XPS measurement. For GIXPS measurements, the x-ray tube was mounted on the radial track with angular adjustment to focus the x-ray beam at a low angle of incidence (grazing incidence) relative to the sample surface plane. This gave an angular resolution of 0.1°.

AES was performed in a similar chamber but using a three grid LEED optics as energy analyzer. Beam energies of 2.5 keV and a current 4  $\mu\text{A}$  were used. An ion gun is also available for ion milling or bombardment of the surface to remove contamination. The ion milling procedure is done for depth profile studies of the surface. The ion gun may be introduced into any port of the chamber and the sample holder is just rotated until the sample is in the direct line of the ion beam for the ion milling procedure.

Depth profile studies of the sample surface were carried out by monitoring the composition of the surface using AES. The surface was ion bombarded with a geometrically increasing ion dose. The elemental intensities as a function of ion dose was measured and the thickness of the oxide layer was deduced.

Elemental identification using AES is routine but compositional analysis is mainly qualitative. A quantitative study of the chemical states on the surfaces is often tedious since the quantitative analyses involve considerations of the elemental sensitivity factors and inelastic mean free paths which are available from reference standards.



Table 1. Major advantages and limitations of AES and XPS.

	AES	XPS
Advantages	Sensitive to 2-20 monolayers Can detect <i>ca.</i> $10^{-3}$ atomic fraction Has a sensitivity range within a factor of 20	
	Has superb lateral resolution Can acquire data rapidly Gives chemical information for some elements	Has minimal sample charging Least destructive of all techniques Useful for chemical states of the same element in different compounds
Limitations	May alter surface composition Severe charging problems for nonconducting elements	Has moderate lateral resolution Slower depth profiling than other methods

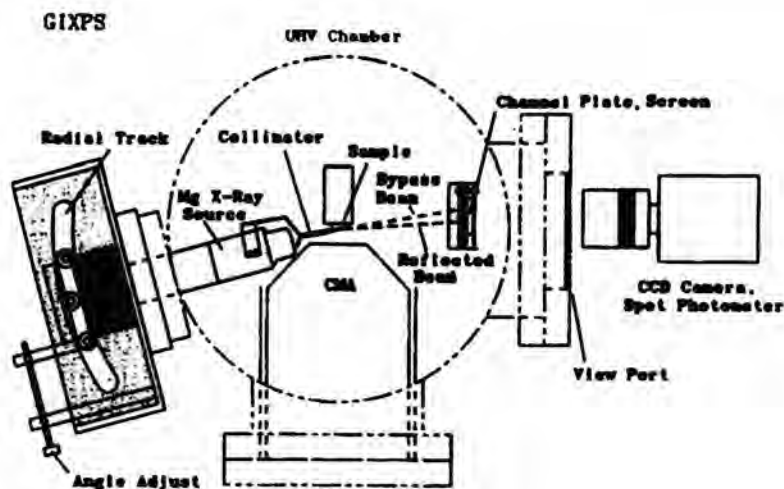


Figure 3. Experimental apparatus

Chemical state information of a surface is best obtained using XPS. However, as the incidence angle of the x-rays is increased, the x-ray penetration depth increases and the photoelectron yields contain a larger contribution from deeper layers within the sample. For XPS x-rays, the refractive indices of materials are slightly less than unity so that a beam of x-ray incident on a flat surface at small incidence angles ( $< 3^\circ$ ) undergoes total external reflection. GIXPS takes advantage of this property. Hence there is an enhancement of photoelectron yields from the surface region.

Figure 4 shows a plate image of the reflected x-ray beam from a GaAs wafer with a standard commercial polish and the bypass beam when the sample holder

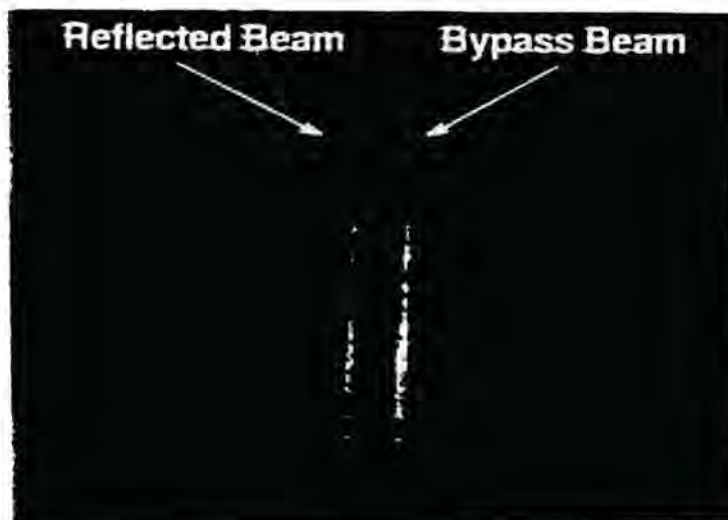


Figure 4. Channel plate image of bypass x-ray beam and reflected beam from a GaAs wafer with a standard commercial polish.

was slightly rotated so that the x-ray did not hit the sample. It may be seen that the intensities of the beams are very similar indicating the total external reflection of x-rays.

Chemical information from XPS is obtained from the peak intensities of photoelectrons from specific elements. Electrons in atoms have definite binding energies so that with a constant x-ray source energy, the photoelectrons have definite kinetic energies. Thus for pure elemental samples the photoelectron distribution is very narrow, occurring at definite energies. Standard peak positions are available for many elements. The peak distribution assumes a normal Gaussian Lorentzian distribution.

If the elements are present in different compounds, the electron binding energies are shifted reflecting the chemical environment. The photoelectron peak distributions are shifted. Because the photoelectron yields come from the pure elements and the compound atoms, the peaks assume broad and skewed line shapes. Curve fitting is done by assuming the superposition of several normal Gaussian distributions under the observed broad peaks. Each fitted Gaussian distribution corresponds to a definite chemical state with known binding energy. Thus the chemical species on the surface may be determined as well as their concentrations based on the relative areas (or intensities) under the peak distribution.

Several InP (100) wafers were prepared using different etches. Chemical polishing was performed using 0.1-2.0% Br in methanol solutions followed by etching in either acidic or basic solutions. The acidic etchants used were mainly HF or HNO<sub>3</sub> while the basic etchant was 1M NaOH. All reagents used were analytical grade in their normal commercial concentrations. Etching time was 2.0 min for all

etches and the samples were dried in a stream of dry nitrogen and immediately inserted into the UHV chamber.

### RESULTS AND DATA ANALYSIS

Figure 5 shows AES derivative spectra from the different surface preparations. The derivative spectra were analyzed because the direct spectra were very broad. The  $\text{Ar}^+$  ion bombarded surface may be considered to be clean or contamination-free since the bombardment procedure would have sputtered off the contaminants. The main features of the clean surface are the P and In valence peaks at 120 and 430 eV respectively. Indium satellite peaks in the lower energy side of In are due to Auger electrons coming from deeper levels of the atom. Shorter spectra with small energy intervals for the different valence Auger electrons of P, C, In, and O were also obtained.

The contaminants on the etched surface are mainly carbon and oxygen. It can be seen that the NaOH etched surface contains large oxygen contamination and minimal carbon coverage while the HF etched surface has larger carbon coverage and less oxygen contamination.

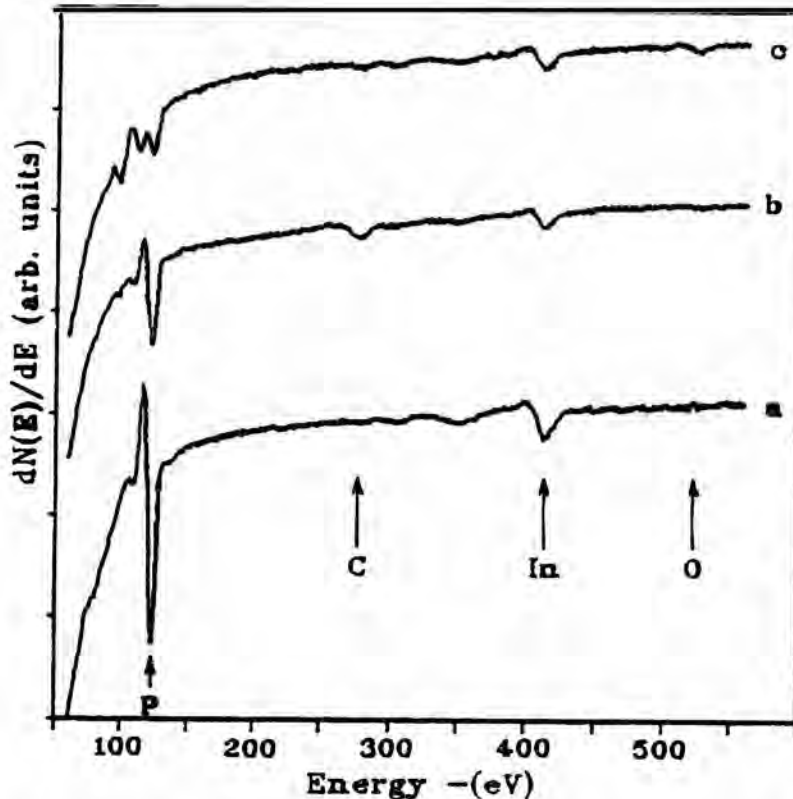


Figure 5. Auger spectra from InP for various surface treatments: (a)  $\text{Ar}^+$  ion bombarded; (b) HF etched; and (c) NaOH etched.

Depth profile studies of the etched surfaces were performed with cumulative bombarding times of 0.5, 1, 2, 4, 8, 16, 32, and 60 min. Intensity measurements on the AES spectra after each bombardment procedure were obtained and shown in Figure 6. Based on the increase in the phosphorus intensity and using an escape depth of 0.966 nm for phosphorus Auger electrons in  $\text{InP}^4$ , the approximate oxide thicknesses for the different surface treatments were deduced and shown in Table 2.

The oxygen coverage on the NaOH etched surface is quite different from that of the HF etched surface. Careful inspection of the oxygen peaks in both surfaces shows that the oxygen peak position of the NaOH etched spectrum is different from the HF etched spectrum. Moreover, the satellite peaks on the lower energy side of the phosphorus peak of the NaOH etched spectrum are indicative of interatomic transitions<sup>5</sup> during the Auger decay. The interatomic transition arises when an electron from the oxygen fills the initial vacancy created in the phosphorus. This

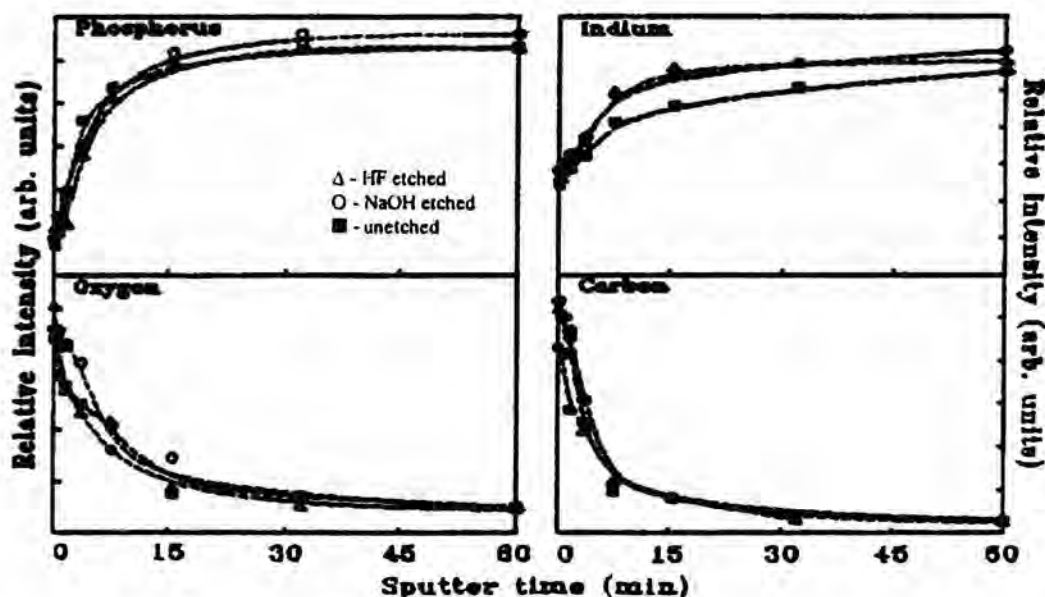


Figure 6. Depth profile of HF, NaOH, and unetched InP samples.

Table 2. Native oxide thickness on InP obtained by different surface treatments.

Surface Treatment	Oxide Thickness
HF etched*	$1.5 \pm 0.2$ nm
NaOH etched*	$2.3 \pm 0.4$ nm
HNO <sub>3</sub> etched <sup>†</sup>	$1.8 \pm 0.1$ nm

\*AES + GIXPS

is possible because of the proximity of oxygen to phosphorus in compounds of phosphorus oxides ( $P_xO_y$ ). For the HF etched surface which has the minimum oxygen coverage, careful analysis of the oxygen peaks in the depth profile spectra gave an approximate oxygen coverage of about 14%. Oxygen levels in the NaOH etched surface are obviously larger.

Spectra from the GIXPS on the  $HNO_3$  etched sample were taken at six angles of incidence for each of the following lines: in  $3d_{5/2}$ , O 1s, P 2p, and C 1s. The photoemission peaks were fitted for the compounds reported by Hollinger et al.<sup>6</sup> to be stable compounds on the surface of InP. These are  $In_2O_3$ ,  $InPO_4$ ,  $In(OH)_3$ ,  $H_2O$ , and C. However, binding energies assigned by Thurgate and Erickson<sup>7</sup> which are slightly modified from the values of Hollinger et al.<sup>6</sup> were used. Figure 7 shows a sample spectrum of the In  $3d_{5/2}$  line taken at an incidence angle of 55 mrad. The spectrum shows the photoemission peak and the fits of the different chemically shifted constituents.

Simultaneously fitting procedures were also performed on the other spectral lines. By analyzing the fits for the elements that are correlated in a single compound, several observations were made:

1. The surface was covered in a single thin layer. The oxide had not separated into distinct component layers of  $InPO_4$  and  $In_2O_3$  as reported for thicker oxides<sup>8</sup>.

2. The overlayer had a thickness of 1.8 nm (assuming a mean free path of 2.0 nm) in the overlayer for an electron with a kinetic energy of 1250 eV), a composition of 83% C, 13% O, 4% In, and a density equal to the density of the substrate.

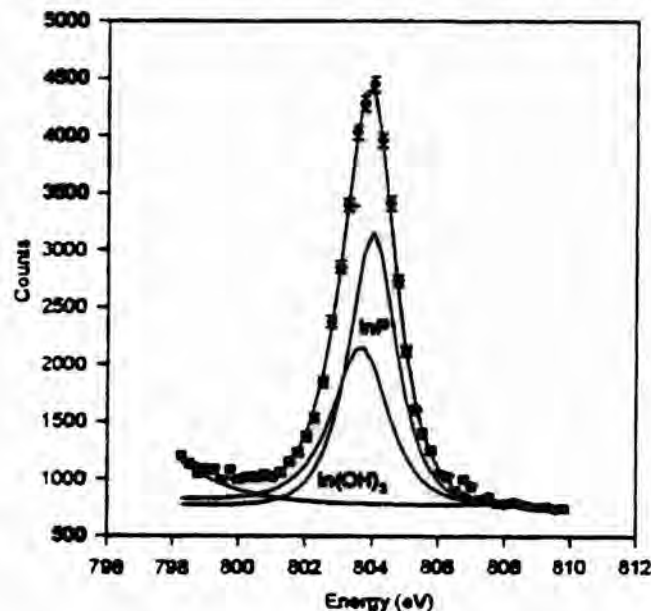


Figure 7. Decomposition of the Indium  $3d_{5/2}$  line with an incidence angle of 55 mrad. The In component of  $InPO_4$  is so small that it has not been included.

## CONCLUSIONS

From this study, it was observed that acidic solutions produce thinner oxides than basic solutions. On the other hand there is larger carbon contamination in the acidic etch but larger oxygen incorporation in a basic etch. The kinetics of the dissolution of elements on the surface may be considered. The dissolution of InP to phosphoric acids is thermodynamically favorable<sup>9</sup> in acidic media and is discharged into the solution until it becomes saturated with the aqueous phosphates. This leaves the surface indium rich in the form of hydrated indium oxides<sup>10</sup> which in turn readily absorb CO<sub>2</sub> from the atmosphere. This explains the high carbon coverage in the acidic etches.

In the basic solutions, phosphates appear in the form of HPO<sub>4</sub><sup>2-</sup> and PO<sub>4</sub><sup>3-</sup> which in the presence of the hydroxyl ions (OH<sup>-</sup>), reprecipitate<sup>9</sup> onto the surface. This accounts for the large quantities of phosphate species on the NaOH etched surface. The phosphate surface covers the indium oxides preventing them from absorbing large amounts of carbon dioxide.

Finally, since the GIXPS technique provided a surface sensitive chemical analysis of the sample, the observed phosphorus peak from the AES study of the HF etched surface may be considered to emanate from deeper levels. This is not surprising since the electron beam used in AES is at normal incidence to the surface and therefore has greater penetration depths.

We conclude that acidic etchants produce thin oxide overlayers on InP. This is in agreement with the results on InP obtained by Kirk and Jones<sup>11</sup>. It is viable to use acidic etchants for InP water preparation to obtain thin oxide layers. However, this layer consists of a heterogeneous mixture of In(OH)<sub>3</sub>, and In<sub>2</sub>O<sub>3</sub>, C, and very little InPO<sub>4</sub>. This surface looked similar to the surface prepared and analyzed using angle resolved XPS by Zemek et al.<sup>12</sup> The presence of indium phosphate as found by Hollinger et al.<sup>6</sup> may be located at the InP substrate but beneath the indium hydroxide.

Finally, GIXPS and AES are complementary techniques that provide very good compositional and chemical analyses of very thin oxide layers.

## ACKNOWLEDGMENTS

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## **RUNGE-KUTTA METHODS AND UNIFORMLY REGULAR MATRICES**

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### **ABSTRACT**

Uniformly regular matrices can be used for approximating the integral of the a function on a given interval. Considering that Runge-Kutta methods use weights to arrive at an approximation to the solution of a differential equation, whenever it exists, applying uniformly regular matrices to Runge-Kutta methods is a natural step to take. The class of uniformly regular matrices is large so we ask what properties do we need to have to be able to use such matrices. This paper gives sufficient conditions for the application of uniformly regular matrices to Runge-Kutta methods of order 2 and order 3 as well as some examples.

Uniformly regular matrices were used by Lee [5] and Lagare [2, 3, and 4] to find the approximation of the integration of a given function  $f$  on the interval  $[a, b]$ . Knowing the intimate connection between integrals and solutions to differential equations, it is natural to ask if uniformly regular matrices can be used to approximate the solution to a differential equation.

One way of solving a differential equation is to use integration methods and this is essentially covered in the above works. Another method we can apply uniformly regular matrices to is Runge-Kutta methods. This is because Runge-Kutta methods use weight in the algorithm to approximate the solution to the given differential equation. In this paper, we give sufficient conditions

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on uniformly regular matrices so they can be used for Runge-Kutta methods of orders 2 and 3. We also give an example showing several computations approximating the solution to a differential equation.

Runge-Kutta methods are self-starting methods and are easy to program on a computer but it is at a disadvantage when error-estimation and speed are considered. When the derivative is simple, Runge-Kutta methods can be competitive in terms of speed. Moreover, by using additional evaluations of the function, a good error estimate can be obtained. The objective of this paper is to find a way of cheaply finding the weights for the method that will contribute to its further use.

Given a differential equation

$$\frac{dy}{dx} = f(x, y) \quad y(x_0) = y_0,$$

we assume it to possess a solution,  $y(x)$ , which is unique, continuous, and differentiable on  $[x_0, b]$ . Then Runge-Kutta methods can be generally written (c.f. [1] and [6]) as

$$y_{n+1} = y_n + \sum_{i=1}^m \omega_i k_i \quad (1)$$

where the  $\omega_i$ 's are constants and

$$k_i = hf \left( x_n + \alpha_i h, y_n + \sum_{j=1}^{i-1} \beta_{ij} k_j \right)$$

with  $h$  denoting the difference and

$$x_{k+1} - x_k, x_0 < x_1 < \dots < x_l = b.$$

The  $\omega_i$ 's,  $\alpha_i$ 's and  $\beta_{ij}$ 's are referred to as the parameters of the method.

The Taylor's Series expansion of  $y_{n+1}$  in (1) can be written as

$$y_{n+1} = y_n + \sum_{t=1}^{\infty} h^t y_n^{(t)} / t!$$

where

$$\begin{aligned} y_n^{(t)} &= \frac{d^{t-1}}{dx^{t-1}} f(x_n, y_n) = \left( \frac{\partial}{\partial x} + \frac{dy}{dx} \frac{\partial}{\partial y} \right)^{t-1} f(x_n, y_n) \\ &= \left( \frac{\partial}{\partial x} + f(x, y) \frac{\partial}{\partial y} \right)^{t-1} f(x_n, y_n). \end{aligned}$$

On the other hand, the expansion for

$$f\left(x_n + \alpha_i h, y_n + \sum_{j=1}^{i-1} \beta_{ij} k_j\right)$$

is given by

$$f\left(x_n + \alpha_i h, y_n + \sum_{j=1}^{i-1} \beta_{ij} k_j\right) = \sum_{t=1}^{\infty} \left[ h D_i + \sum_{j=2}^{i-1} \beta_{ij} (k_j - h f(x_n, y_n)) \frac{\partial}{\partial x} \right]^t f(x_n, y_n) / t!$$

where

$$D_i = \alpha_i \frac{\partial}{\partial x} + \left( \sum_{j=1}^{i-1} \beta_{ij} \right) f(x_n, y_n) \frac{\partial}{\partial y}.$$

Equating the left- and right-hand sides of (1) and matching the corresponding powers of  $h$ , we obtain a system of equations that will allow us to solve for the values of the  $\omega_i$ 's,  $\alpha_i$ 's, and  $\beta_{ij}$ 's. The order of the method will be the highest power  $m$  of  $h$  which we decide to retain in our expansion.

For Runge-Kutta methods of orders 2 and 3, we obtain the following systems:

For  $m = 2$ :

$$\begin{aligned} \omega_1 + \omega_2 &= 1 \\ \alpha_1 \omega_2 &= 1/2 \\ \alpha_2 &= \beta_{21} \end{aligned} \tag{2}$$

Form  $m = 3$ :

$$\begin{aligned} \omega_1 + \omega_2 + \omega_3 &= 1 \\ \alpha_2 \omega_2 + \alpha_3 \omega_3 &= 1/2 \\ \alpha_2^2 \omega_2 + \alpha_3^2 \omega_3 &= 1/3 \\ \alpha_2 \beta_{32} \omega_3 &= 1/6 \\ \alpha_2 &= \beta_{21} \\ \alpha_2 &= \beta_{31} + \beta_{32}. \end{aligned} \tag{3}$$

Each of the above systems have more variables than there are equations, so we can choose the free parameters to suit desired properties we want in the method.

Now let  $A = (a_{n,k})$  be a row-finite matrix, that is,  $a_{n,m(n)} \neq 0$  for all  $n$ , and  $a_{n,k} = 0$  when  $k > m(n)$ . A row-finite matrix  $A$  is said to be uniformly regular if it satisfies the following three conditions:

$$(i) \quad \lim_{n \rightarrow \infty} a_{n,k} = 0 \text{ uniformly in } k,$$

$$(ii) \quad \lim_{n \rightarrow \infty} \sum_{k=1}^{m(n)} a_{n,k} = 1, \text{ and}$$

$$(iii) \quad \sup_{n \geq 1} \sum_{k=1}^{m(n)} |a_{n,k}| < +\infty.$$

**Theorem:** Let  $A$  be a uniformly regular matrix whose  $i$ th row satisfies the following:

- $a_{ij_1} > 0, a_{ij_2} > 0, a_{ij_3} > 0$  and  $a_{ij_k} = 0$  for  $k \neq 1, 2, 3$ ;
- $a_{ij_3} \neq 3/4$ ;
- $a_{ij_2} + a_{ij_3} \geq 3/4$ ; and
- $a_{ij_1} + a_{ij_2} + a_{ij_3} = 1$ .

Then the  $i$ th row can be used for the values of the parameters  $\omega_1, \omega_2$ , and  $\omega_3$  of a Runge-Kutta method of order 3, with  $\omega_1 = a_{ij_1}$ ,  $\omega_2 = a_{ij_2}$ , and  $\omega_3 = a_{ij_3}$ . The values of the other parameters can be found using (3) and the values of  $\omega_2$  and  $\omega_3$ .

For an order 2 method, the sufficient conditions are:  $a_{ij_1} + a_{ij_2} = 1$  and  $a_{ij_1} \neq 0$  with  $a_{ij_k} = 0$  for  $k \neq 1, 2$ .

**Proof:** Solve the systems (2) and (3) and use the results with the properties of uniformly regular matrices.

**Example:** Given the initial value problem

$$y'(x) = y(x), y(0) = 1, b = 2.$$

The solution to the differential equation at the point  $x = 2$  using Runge-Kutta methods of orders 2 and 3 are as follows:

**R-K Order 2,  $h = 1.0$** 

Parameters				
$y_n$	$\omega_1 = 0; \omega_2 = 1;$ $\alpha_2 = 0.5; \beta_{21} = 0.5$	$\omega_1 = 0.25; \omega_2 = 0.75;$ $\alpha_2 = 0.666666666666667;$ $\beta_{21} = 0.666666666666667$	$\omega_1 = 0.5; \omega_2 = 0.5;$ $\alpha_2 = 1; \beta_{21} = 1$	$\omega_1 = 0.3; \omega_2 = 0.7;$ $\alpha_2 = 0.7142875;$ $\beta_{21} = 0.7142875$
$y_1$	2.500000000000000	2.500000000000000	2.500000000000000	2.500001250000000
$y_2$	6.250000000000000	6.250000000000000	6.250000000000000	6.25000625000156

**R-K Order 2,  $h = 0.5$** 

Parameters				
$y_n$	$\omega_1 = 0; \omega_2 = 1;$ $\alpha_2 = 0.5; \beta_{21} = 0.5$	$\omega_1 = 0.25; \omega_2 = 0.75;$ $\alpha_2 = 0.666666666666667;$ $\beta_{21} = 0.666666666666667$	$\omega_1 = 0.5; \omega_2 = 0.5;$ $\alpha_2 = 1; \beta_{21} = 1$	$\omega_1 = 0.3; \omega_2 = 0.7;$ $\alpha_2 = 0.7142875;$ $\beta_{21} = 0.7142875$
$y_1$	1.625000000000000	1.625000000000000	1.625000000000000	1.625000312500000
$y_2$	2.640625000000000	2.640625000000000	2.640625000000000	2.64062601562510
$y_3$	4.291015625000000	4.291015625000000	4.291015625000000	4.29101810058641
$y_4$	6.972900390625000	6.972900390625000	6.972900390625000	6.97290575439608

**R-K Order 2,  $h = 0.25$** 

Parameters				
$y_n$	$\omega_1 = 0; \omega_2 = 1;$ $\alpha_2 = 0.5; \beta_{21} = 0.5$	$\omega_1 = 0.25; \omega_2 = 0.75;$ $\alpha_2 = 0.666666666666667;$ $\beta_{21} = 0.666666666666667$	$\omega_1 = 0.5; \omega_2 = 0.5;$ $\alpha_2 = 1; \beta_{21} = 1$	$\omega_1 = 0.3; \omega_2 = 0.7;$ $\alpha_2 = 0.7142875;$ $\beta_{21} = 0.7142875$
$y_1$	1.281250000000000	1.281250000000000	1.281250000000000	1.281250078125000
$y_2$	1.641601562500000	1.641601562500000	1.641601562500000	1.64160176269532
$y_3$	2.10330200195313	2.10330200195313	2.10330200195313	2.10330238670352

**R-K Order 2,  $h = 0.25$  (continued)**

Parameters				
$y_4$	2.69485569000244	2.69485569000244	2.69485569000244	2.69485634728438
$y_5$	3.45278385281563	3.45278385281563	3.45278385281563	3.45278490549376
$y_6$	4.42387931142002	4.42387931142002	4.42387931142002	4.42388092991270
$y_7$	5.66809536775691	5.66809536775691	5.66809536775691	5.66809778706635
$y_8$	7.26224718993854	7.26224718993854	7.26224718993854	7.26225073249890

**R-K Order 3,  $h = 1.0$**

Parameters				
$y_n$	$\omega_1=0.22222222222222$ $\omega_2=0.33333333333333$ $\omega_3=0.444444444444$ $\alpha_2 = 0.5; \alpha_3 = 0.75;$ $\beta_{21} = 0.5;$ $\beta_{31} = 0; \beta_{32} = 0.75;$	$\omega_1 = 0.1666666666667;$ $\omega_2 = 0.6666666666667;$ $\omega_3 = 0.1666666666667;$ $\alpha_2 = 0.5; \alpha_3 = 1.0;$ $\beta_{21} = 0.5;$ $\beta_{31} = -1.0; \beta_{32} = 2.0;$	$\omega_1= 0.2; \omega_2=0.4; \omega_3=0.4$ $\alpha_2 = 0.46362569390802;$ $\alpha_3 = 0.78637430609198;$ $\beta_{21} = 0.46362569390802;$ $\beta_{31} = -0.112339186584578;$ $\beta_{32} = 0.89871349267654;$	$\omega_1 = 0.2; \omega_2=0.4; \omega_3=0.4$ $\alpha_2 = 0.78637430609198;$ $\alpha_3 = 0.46362569390802;$ $\beta_{21} = 0.78637430609198;$ $\beta_{31} = -0.066232241986861;$ $\beta_{32} = 0.52985793589488;$
$y_1$	2.6666666666667	2.6666666666666	2.6666666666666	2.6666666666667
$y_2$	7.11111111111111	7.11111111111111	7.11111111111108	7.11111111111111

**R-K Order 3,  $h = 0.5$**

Parameters				
$y_n$	$\omega_1 = 0.22222222222222$ $\omega_2 = 0.33333333333333$ $\omega_3 = 0.444444444444$ $\alpha_2 = 0.5; \alpha_3 = 0.75;$ $\beta_{21} = 0.5;$ $\beta_{31} = 0; \beta_{32} = 0.75;$	$\omega_1 = 0.1666666666667;$ $\omega_2 = 0.6666666666667;$ $\omega_3 = 0.1666666666667;$ $\alpha_2 = 0.5; \alpha_3 = 1.0;$ $\beta_{21} = 0.5;$ $\beta_{31} = -1.0; \beta_{32} = 2.0;$	$\omega_1 = 0.2; \omega_2=0.4; \omega_3=0.4$ $\alpha_2 = 0.46362569390802;$ $\alpha_3 = 0.78637430609198;$ $\beta_{21} = 0.46362569390802;$ $\beta_{31} = -0.112339186584578;$ $\beta_{32} = 0.89871349267654;$	$\omega_1 = 0.2; \omega_2=0.4; \omega_3=0.4$ $\alpha_2 = 0.78637430609198;$ $\alpha_3 = 0.46362569390802;$ $\beta_{21} = 0.78637430609198;$ $\beta_{31} = -0.066232241986861;$ $\beta_{32} = 0.52985793589488;$

**R-K Order 3,  $h = 0.5$  (continued)**

Parameters				
$y_1$	1.64583333333333	1.64583333333333	1.64583333333333	1.64583333333333
$y_2$	2.70876736111111	2.70876736111111	2.70876736111111	2.70876736111111
$y_3$	4.45817961516204	4.45817961516204	4.45817961516203	4.45817961516204
$y_4$	7.33742061662085	7.33742061662085	7.33742061662083	7.33742061662085

**R-K Order 3,  $h = 0.25$**

Parameters				
$y_n$	$\omega_1 = 0.222222222222222$ $\omega_2 = 0.333333333333333$ $\omega_3 = 0.444444444444444$ $\alpha_2 = 0.5; \alpha_3 = 0.75;$ $\beta_{21} = 0.5;$ $\beta_{31} = 0; \beta_{32} = 0.75;$	$\omega_1 = 0.166666666666667$ 7; $\omega_2 = 0.666666666666667$ 7; $\omega_3 = 0.166666666666667$ 7; $\alpha_2 = 0.5; \alpha_3 = 1.0;$ $\beta_2 = 0.5;$ $\beta_{31} = -1.0; \beta_{32} = 2.0$	$\omega_1 = 0.2; \omega_2 = 0.4; \omega_3 = 0.4$ $\alpha_2 = 0.46362569390802;$ $\alpha_3 = 0.78637430609198;$ $\beta_{21} = 0.46362569390802$ ; $\beta_{31} = -0.112339186584578;$ $\beta_{32} = 0.89871349267654;$	$\omega_1 = 0.2; \omega_2 = 0.4; \omega_3 = 0.4$ $\alpha_2 = 0.78637430609198;$ $\alpha_3 = 0.46362569390$ ; $\beta_{21} = 0.78637430609198;$ $\beta_{31} = -0.066232241986861;$ $\beta_{32} = 0.52985793589488;$
$y_1$	1.28385416666667	1.28385416666667	1.28385416666667	1.28385416666667
$y_2$	1.64828152126736	1.64828152126736	1.64828152126736	1.64828152126736
$y_3$	2.11615309891877	2.11615309891877	2.11615309891877	2.11615309891877
$y_4$	2.71683197335145	2.71683197335145	2.71683197335144	2.71683197335145
$y_5$	3.48801604912048	3.48801604912048	3.48801604912047	3.48801604912048
$y_6$	4.47810393806353	4.47810393806353	4.47810393806352	4.47810393806353
$y_7$	5.74923239964927	5.74923239964927	5.74923239964926	5.74923239964927
$y_8$	7.38117597142471	7.38117597142471	7.38117597142470	7.38117597142472

The results in the first two columns in each table are obtained using popularly recommended Runge-Kutta methods while the ones in the last two columns are Runge-Kutta methods using parameters selected based on the theorem stated above. Note that the results from the last two methods are similar or slightly better than the recommended methods.

Although the performance of the methods using the theorem in this paper is encouraging, there are still a lot of things we may want to know before we can recommend such methods with confidence. For instance, we may ask questions on stability. Are the methods obtained generally stable? If not, to what class do we limit our problem to obtain stability? How about higher order methods? We hope these questions can be answered to further simplify the use of Runge-Kutta methods.

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**A STUDY OF THE ELECTRON-TRANSFER REACTION OF  
*bis*-(*N,N'*-DIBENZYL-THIOUREA) DICHLOROCOBALT (II)  
 AND *bis*-(*N,N'*-DIBENZYL-THIOUREA)  
 DIBROMOCOBALT (II) IN NONAQUEOUS  
 SOLUTIONS WITH HEXACYANOFERRATE (III)**

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**ABSTRACT**

The electronic absorption spectra of the solutions of *bis*-(*N,N'*-dibenzylthiourea)-dichlorocobalt(II),  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$ , and *bis*-(*N,N'*-dibenzylthiourea)dibromocobalt(II),  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  in acetone, acetonitrile, and ethanol were measured. Aqueous  $\text{K}_3[\text{Fe}(\text{CN})_6]$  was added in measured amounts to each of the solutions. The absorption spectra were measured at definite time intervals to monitor changes in the absorption peaks. The formation of a bridged intermediate for the transfer of electron from the cobalt (II) moiety to  $[\text{Fe}(\text{CN})_6]^{3-}$ , similar to those reported in the literature for other cobalt (II) complexes, was evident. The change with time in the absorbance at the maximum wavelength of the intermediate was measured to determine the rate of formation and decomposition of the bridged complex.

The capability of the cobalt(III)-cobalt(II) system when stabilized by organic ligands, to transport oxygen molecule analogous to the Fe(III) – Fe(II) system in hemoglobin has aroused the interest of quite a number of researchers. The role of the cobalt(III) – cobalt(II) couple in catalyzing reactions has also been studied especially in biochemical reactions (1-7). The kinetics of the reduction of cobalt(III) has been the subject of many studies (8-19, 26-32) the studies cited focusing on the determination of the order of reaction in the formation of a bridged intermediate, with the subsequent decomposition. This study approaches the Co(III)-Co(II) equilibrium from the reversed direction, i.e., the spectroscopic study of cobalt(II)-cobalt(III) system in nonaqueous solution. The starting complex, *bis*-(*N,N'*-dibenzylthiourea)dichlorocobalt(II), hitherto referred to as  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$ , and *bis*-(*N,N'*-dibenzylthiourea)dibromocobalt(II), hitherto referred to as  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  are pseudotetrahedral complexes. The previous studies so far started on octahedral cobalt(III) complexes. The spectroscopic properties of the



test complexes were reported earlier (20-21); and the reaction of the diphenylthiourea analog  $[(\text{Co}(\text{diphenztu})_2, \text{Cl}_2)]$  with solid oxidizing agents was the subject of a previous study (22). The changes in the spectroscopic properties of solutions of the complexes in acetone, acetonitrile, and ethanol are reported here along with initial attempts to study the rates of the decomposition of the bridged intermediate.

## EXPERIMENTAL

**Materials.** *N,N'*-dibenzylthiourea was prepared following the standard procedure of preparing thiourea derivatives (23). 46.8 mL of benzylamine, 40.0 mL of carbon disulfide and 63.5 mL 5% ethanol were cautiously mixed in a 500-mL round bottom flask provided with an efficient double surface condenser. The apparatus was set up in a hood. An absorption device containing 1 M  $\text{CuSO}_4$  and 6 M HCl was attached to the top of the condenser to absorb the  $\text{H}_2\text{S}$  which was evolved. The solution of benzylamine and  $\text{CS}_2$  in ethanol was refluxed for eight hours, then the excess  $\text{CS}_2$  and ethanol was distilled off. The residue was washed with excess 1:10 HCl to remove the unreacted benzylamine, filtered, washed with distilled water and drained well. The crystals were dried at  $80^\circ\text{C}$  in the oven. Further purification was done by dissolving the crystals with minimum hot ethanol, under reflux. The solution was filtered while hot. The filtrate was cooled in ice water. The needle-like crystals were filtered, washed with hot water, and dried in the oven at  $80^\circ\text{C}$ . The crystals were stored in an amber bottle.

The complexes were prepared by mixing a solution of cobalt chloride/cobalt bromide in anhydrous ethanol with a solution of *N,N'*-dibenzylthiourea in anhydrous dichloroethane in a molar ratio 1 cobalt salt to 2 of dibenzylthiourea. Equal volumes of the solution were used. The resulting mixture was heated in a steam bath under reflux. Then the solution was concentrated in a rotary evaporator until crystals appeared which were then filtered off and dried between filter papers. The crystallization was done with dichloroethane.

Analytical grade  $\text{K}_3[\text{Fe}(\text{CN})_6]$  crystals were used to prepare the 0.001 M aqueous solution.

**Apparatus.** The melting points of the complexes were measured using the Beckman melting point apparatus. The Perkin-Elmer model 710A IR spectrophotometer was used to measure the infrared spectra of the ligand and the complexes. The electronic absorption spectra were measured using the Pye-Unicam SP8-100 digital double beam UV-visible spectrophotometer from 200 to 800 nm. For each measurement, the reference used was the corresponding solvent.

**Spectra of the Reacting Solutions.** 3.00 mL of 0.001 M  $[\text{Co}(\text{diphenztu})_2, \text{Cl}_2]/[\text{Co}(\text{diphenztu})_2\text{Br}_2]$  in the corresponding solvent, was placed in the cuvette. 0.04 mL of the oxidizing agent was added, the mixture shaken, and the spectrum was scanned from 200-800 nm immediately after mixing. Then an additional 0.04 mL was added, followed by scanning within the time allowed. The procedure was repeated with an additional 0.04 mL of the oxidizing agent.

**Kinetic Studies.** The spectrophotometer was set at 390 nm for the measurement of change of absorbance with time. 3.00 mL of 0.001 M  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetone was placed in the cuvette. 0.04 mL of the oxidizing agent was added, followed by shaking. The absorbance of the solution was measured every ten seconds.

## RESULTS AND DISCUSSION

**Absorption Spectra of the Complexes in the Region 200-800 nm.** The absorption spectra of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  and  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  in acetone, in acetonitrile, and in ethanol in the region 200 to 800 nm are typical of a pseudo tetrahedral  $[\text{CoL}_2\text{X}_2]$  complex. These spectra are shown in Figures 1 and 2 for  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  and  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  respectively. The absorption band at 600-690 nm is typical  ${}^4\text{A}_2(\text{F}) \rightarrow {}^4\text{T}_1(\text{P})$  transition corresponding to the  $e^4t^3 \rightarrow e^3t^4$ . The peak at 330 nm for the acetone and for the acetonitrile solutions, and at 280 nm for the ethanol solution, is a halide to metal charge-transfer band. The shift to shorter wavelengths for the ethanol solution is expected due to the increasing polarity of the solvent.

The organic ligand, *N,N*-dibenzylthiourea, has a very intense absorption band at 230-235 nm, characteristic of the  $\pi \rightarrow \pi^*$  transition in the aromatic ring. A weaker band is expected at about 280 nm but this has disappeared because of (a) the substitution in the benzene ring, (b) the solvent used, and (c) the dilution. The intense aromatic band at about 230 nm was affected by the solvent used. In Fig. 1, with acetone as the solvent, the absorbance for a 0.001 M solution of the ligand is 1.2 and this was only slightly changed upon coordination with cobalt (II) in both chloride and bromide complexes (Fig. 2). With a slightly more polar solvent, acetonitrile, the absorbance for the same concentration went up to ~ 2.5 and the peak was shifted slightly to 235 nm, but on coordination was shifted even more (240 nm for  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  and 300 nm for  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$ ). The general appearance of this aromatic band also changed when the ligand bonded with Co(II). The intense peak was split and a shoulder appeared at 240 nm. This means that the bonding of the C = S to the metal ion has affected the  $\pi$ -system of the aromatic ring. This effect however, was exhibited only for acetonitrile as solvent. With a more polar solvent such as ethanol, the band returned to its original shape similar to that of the pure ligand in the case of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$ . For  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$ , coordination has decreased the intensity of the band drastically.

As expected, the absorption bands were shifted slightly to longer wavelengths when the halide was changed from chloride to bromide. This shift was more pronounced in the UV region. The splitting and general appearance of the band at 575-685 nm were more affected by a change in halide ion and in solvent.  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  gave a more intense band, almost double that of the chloride analog. The intensity of this band in a tetrahedral cobalt (II) is due to the lack of symmetry of the tetrahedral configuration so that the *d* orbitals mix with *p* orbitals

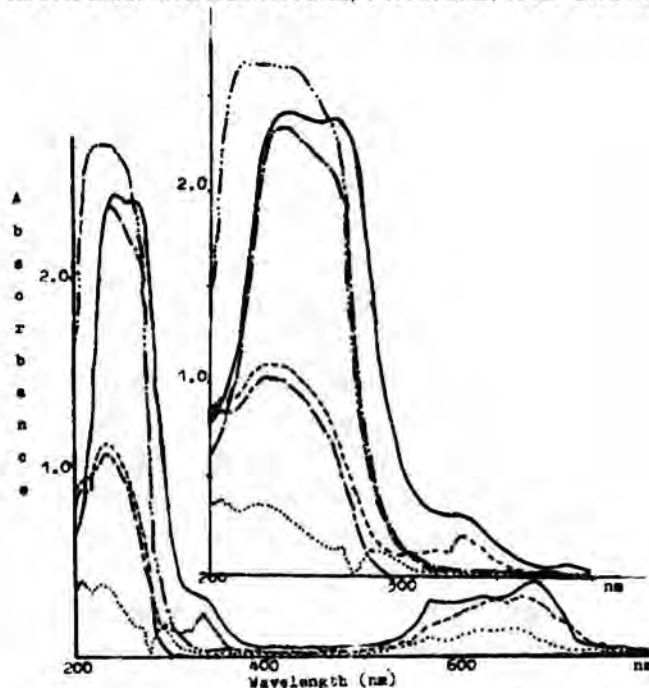


Figure 1. The UV-visible absorption spectra of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile (—), in acetone (----), in ethanol (.....), of dibenzylthiourea in acetonitrile (— · — · —), in acetone (— — — —), in ethanol (— · · · ·).

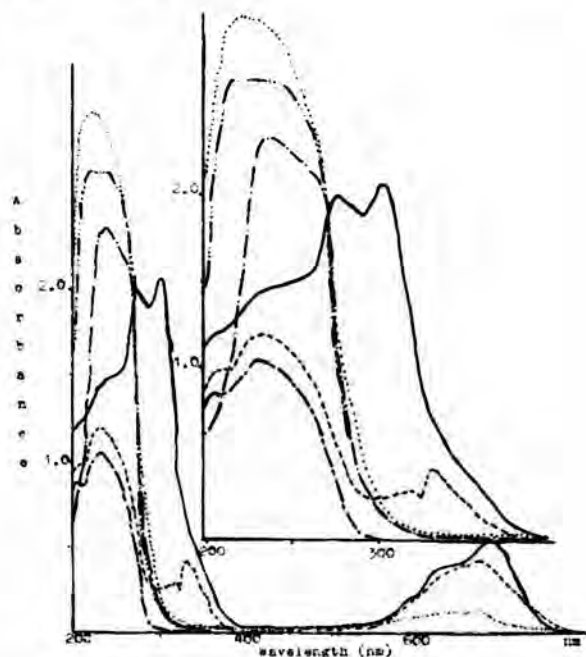


Figure 2. The UV-visible absorption spectra of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  in acetonitrile (—), in acetone (----), in ethanol (.....), of dibenzylthiourea in acetonitrile (— · — · —), in acetone (— — — —), in ethanol (— · · · ·).

(same parity) hence no longer pure  $d$  orbitals, resulting in the lifting of Laporte's rule forbidding pure  $d \rightarrow d$  transitions. Bromide being a larger ion, allows more "mixing" of its  $p$ -orbitals with the  $d$ -orbitals of the central metal ion.

The splitting of the absorption band in the 575-685 nm region is due to spin-orbital coupling of the  $^4P(T_1)$  state.  $[\text{CoCl}_4]^{2-}$  for example, exhibits an unusually detailed splitting into five or six maxima (24). The lack of symmetry of the tetrahedral complex is the reason why spin-orbital coupling is more pronounced. The splitting of the  $d \rightarrow d$  transition band of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  is more pronounced than that of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  complex. The solvents can also obscure this finer structure of the absorption band. Less polar solvents like acetone practically "dampen" this splitting. More polar solvents like ethanol, allow this splitting to be measured, especially in the total absence of water molecules. In Figure 3, the splitting is clearest for  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile.

The absorption band of the solutions of the two complexes and of the pure ligand in acetone, in acetonitrile, and in ethanol, in the region 200-800 nm, are summarized in Table I, along with the assignment of the transitions responsible for the absorption.

**Oxidation with  $[\text{Fe}(\text{CN})_6]^{3-}$ .** The reduction of  $[\text{Fe}(\text{CN})_6]^{3-}$  to  $[\text{Fe}(\text{CN})_6]^{4-}$  by  $[\text{Co}(\text{NH}_3)_6]^{2+}$  is thermodynamically favorable in aqueous solution, the net reaction having a standard emf of 0.26 v at 25°C. With a change of ligand and coordination on cobalt (II) it is expected that the reaction will still be spontaneous.

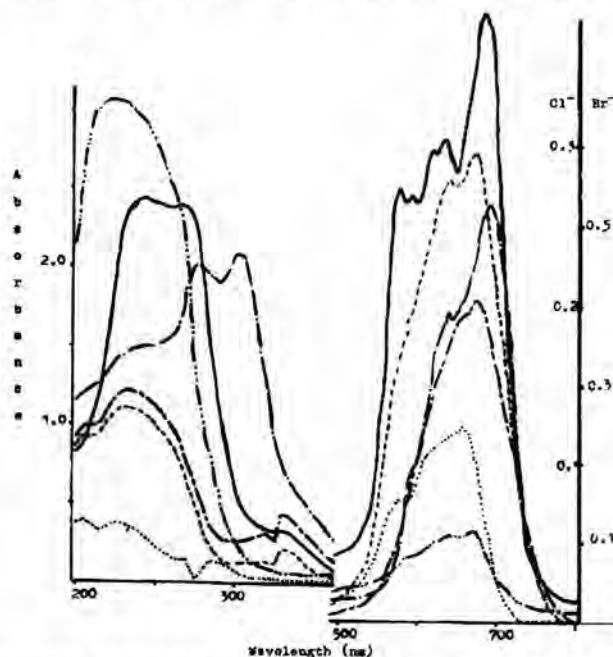
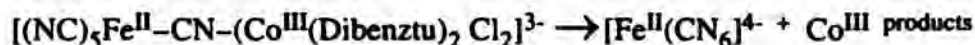
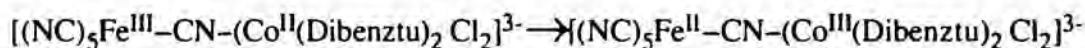
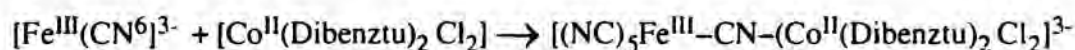


Figure 3. Comparison of the UV-Visible absorption spectra of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile (—), in acetone (----), in ethanol (· · · · ·), of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  in acetonitrile (— · —), in acetone (— — —), in ethanol (— · · · —).

Table I. The maxima of the UV-visible spectra of dibenzylthiourea(dibenztu), [Co(dibenztu)<sub>2</sub>Cl<sub>2</sub>] and [Co(dibenztu)<sub>2</sub>Br<sub>2</sub>] in the three solvents with the corresponding molar extinction (liter per mole per cm) and assigned transitions.

Solvent	Wavelength (molar absorptivity)			Assignment
	Dibenztu	[Co(Dibenztu) <sub>2</sub> Cl <sub>2</sub> ]	[Co(Dibenztu) <sub>2</sub> Br <sub>2</sub> ]	
Acetone		670(296)	670(404)	<sup>4</sup> A <sub>2</sub> (F) → <sup>4</sup> T <sub>1</sub> (P)
		640(278)		
		585(179)		
		330(227)	330(409)	X <sup>-</sup> to Me, CT aromatic π → π*
		230(1045)	235(1197)	
	205(865)	205(924)		
Acetonit- rile		630(384)	685(524)	<sup>4</sup> A <sub>2</sub> (F) → <sup>4</sup> T <sub>1</sub> (P)
		630(305)	635(389)	
		575(273)	590(186)	
		335(308)	355(350)	X <sup>-</sup> to Me, CT aromatic π → π*
		235(2357)	300(2059)	
		265(2392)	275(2003)	
		240(2422)	240(1465)	
Ethanol		655(123)	670(111)	<sup>4</sup> A <sub>2</sub> (F) <sup>4</sup> T <sub>1</sub> (P)
			640(106)	
		580(76)	580(74)	
		285(144)	265(2292)	X <sup>-</sup> to Me, CT aromatic π → π*
		230(2672)	225(3023)	
		205(389)		

A change of solvent however, will slow down the reaction such that it is possible to monitor the change spectrophotometrically especially if one of the reagents is added in very limited amounts. In this study hexacyanoferrate (III) was added to [Co(dibenztu)<sub>2</sub>Cl<sub>2</sub>] and to [Co(dibenztu)<sub>2</sub>Br<sub>2</sub>] in measured amounts but the molar ratio was limited to 1 [Fe(CN<sub>6</sub>)<sup>3-</sup> to 225 Co(II), then 1:112.5, then 1:75. Following the mechanism reported by previous researchers (16, 19, 26-31) the reaction is thought to proceed via the mechanism



The changes in the spectra of the complexes upon the addition of  $[\text{Fe}(\text{CN})_6]^{3-}$  are shown in Figures 4 to 8. With increasing amount of reagent, the intensity of the absorption band at  $\sim 670$  nm decreased proportionately. The intensity of the new band at  $\sim 390$  nm increased with the amount of reagent. If the millimoles of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  left in the solution after each addition of reagent is subtracted from the original millimoles of complex, the millimoles of Co(III), bridged with  $[\text{Fe}(\text{CN})_6]^{3-}$  can be estimated. The results are given in Table 2.

In Table 2, one notices immediately that the more polar the solvent, the more of the divalent complex has been converted to Co(II). The obvious trend that the more reagent added, the more Co(II) complex is oxidized, is affirmed. Only in the less polar solvents acetone and acetonitrile, is the trend 1:2:3, following the mmoles of reagent added, is approximated, but only for  $[\text{Co}(\text{Dibenztu})_2\text{Cl}_2]$ . The bromide is "helping" the  $[\text{Fe}(\text{CN})_6]^{3-}$  so to speak, in oxidizing the Co(II) central atom. The absolute mmoles of oxidized complex however, exceed the mmoles of  $[\text{Fe}(\text{CN})_6]^{3-}$  added, as shown in Table 3. The ratio of conversion is biggest for ethanol, the trend decreasing with more reagent added. The opposite is true for weakly polar acetone as solvent. The ratio of conversion is smallest and the trend is increasing. The increase in conversion ratio is not as much in acetonitrile compared to acetone. In some cases in fact, the ratio decreases. Again, the polarity of the solvent plays a role in the reaction.

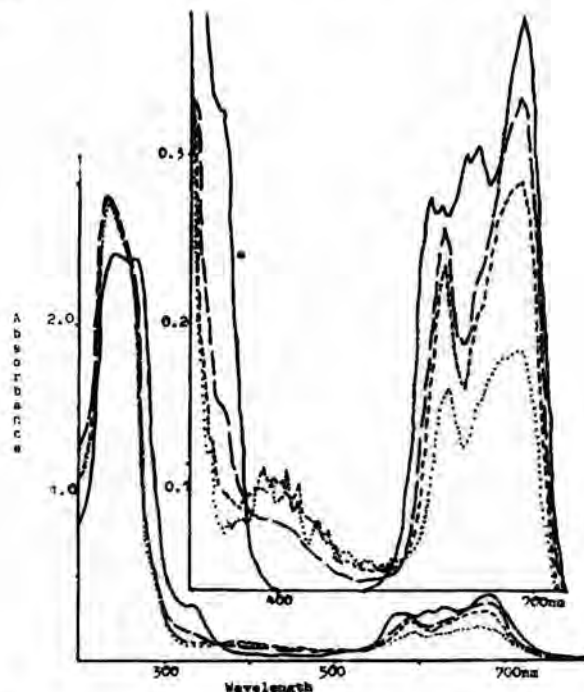


Figure 4. The absorption spectrum of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  acetonitrile (0.001 M (—)), upon addition of 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  to 3.0 mL of complex, 0.04 mL (— — —), 0.08 mL (— — — —), 0.12 mL (· · · · ·). The inset is a magnified absorption spectrum in the visible region..

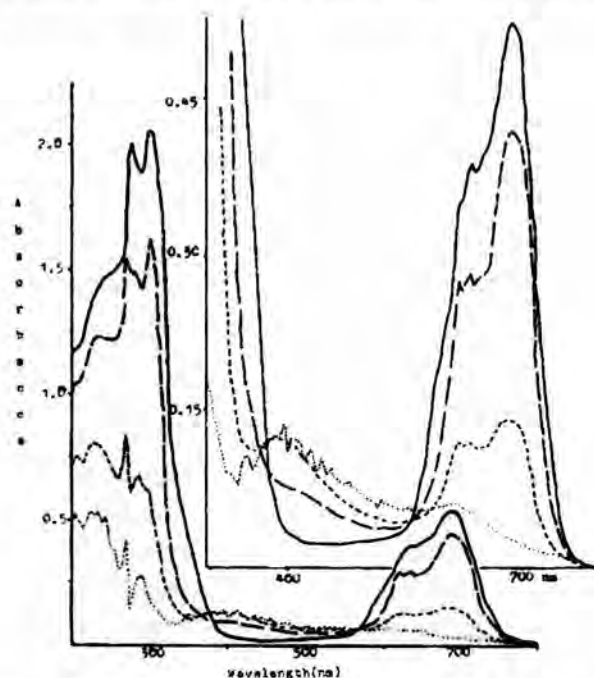


Figure 5. The absorption spectrum of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  acetonitrile (0.001 M (—)), upon addition of 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  to 3.0 mL of complex, 0.04 mL (— —), 0.08 mL (----), 0.12 mL (· · · ·). The inset is a magnified absorption spectrum in the visible region..

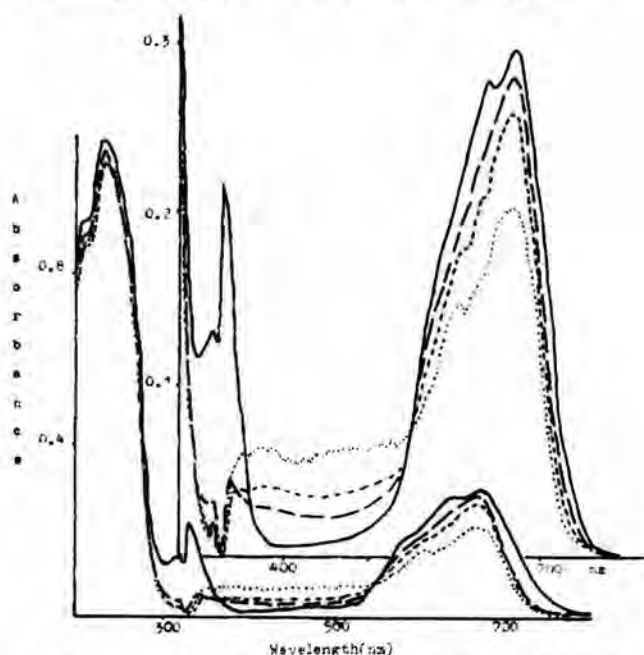


Figure 6. The absorption spectrum of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  acetone (0.001 M (—)), upon addition of 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  to 3.0 mL of complex, 0.04 mL (— —), 0.08 mL (----), 0.12 mL (· · · ·). The inset is a magnified absorption spectrum in the visible region.

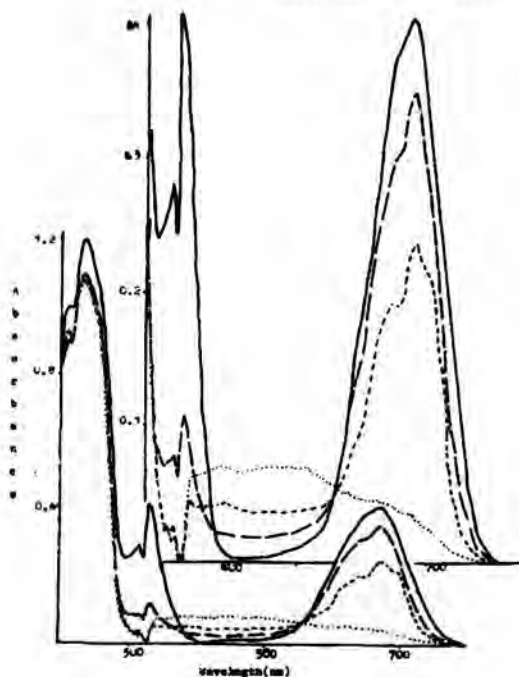


Figure 7. The absorption spectrum of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  acetone (0.001 M (—)), upon addition of 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  to 3.0 mL of complex, 0.04 mL (— — —), 0.08 mL (— — — —), 0.12 mL (· · · · ·). The inset is a magnified absorption spectrum in the visible region..

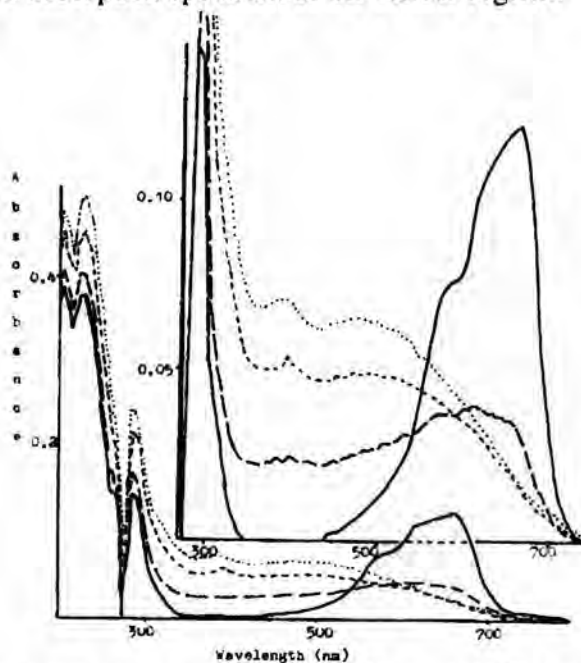


Figure 8. The absorption spectrum of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  ethanol (0.001 M (—)); upon addition of 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  to 3.0 mL of complex, 0.04 mL (— — —), 0.08 mL (— — — —), 0.12 mL (· · · · ·). The inset is a magnified absorption spectrum in the visible region..



Table 2. Millimoles ( $\times 103$ ) Co(II) complex converted to Co(III), obtained from the decrease in absorbance of Co(II) complex after addition of 0.001 M  $K_3[Fe(CN)_6]$ 

Solvent	[Co(dibenztu) $_2$ Cl $_2$ ]			[Co(dibenztu) $_2$ Br $_2$ ]		
	0.04 mL	0.08 mL	0.12 mL	0.04 mL	0.08 mL	0.12 mL
Acetone	1.12	2.9	8.47	3.89	12.04	27.23
Acetonitrile	4.5	7.2	15.3	5.6	21.68	26.41
Ethanol	20.03	24.7	24.88	21.91	22.92	23.48

Table 3. Ratio of mmoles of Co(II) complex converted to Co(III) to the mmoles of  $[Fe(CN)_6]^{3-}$  added to 3.00 mL of 0.001 M complex

Solvent	[Co(dibenztu) $_2$ Cl $_2$ ]			[Co(dibenztu) $_2$ Br $_2$ ]		
	0.04 mL	0.08 mL	0.12 mL	0.04 mL	0.08 mL	0.12 mL
Acetone	2.8	3.6	7.0	9.7	15.0	22.7
Acetonitrile	11.2	9.0	12.8	14.0	27.1	22.0
Ethanol	50.1	30.9	20.8	54.8	28.6	19.6

Both [Co(dibenztu) $_2$ Cl $_2$ ] and [Co(dibenztu) $_2$ Br $_2$ ] show the absorption band at 360-380 nm, which is characteristic of the bridge Co(III) ion, attributed to the  $^1A_{1g} \rightarrow ^1T_{2g}$  transition.

With ethanol as solvent, the bridge intermediate is detectable from the hump at around 500 nm, and the peak at 376 nm, both for the chloride and bromide complexes (Figures 8 and 9). Such a hump is discernible in the acetone solution of both complexes with the difference that the  $d \rightarrow d$  transition band with increasing spin-orbital coupling is still intact, albeit reduced in intensity (Figures 6 and 7). This band practically disappeared in the ethanol solution upon the addition of 0.12 mL 0.001 M  $K_3[Fe(CN)_6]$ .

The acetonitrile solution of each of the complex retained the absorption band at  $\sim 680$  nm (Figures 4 and 5) but with reduced spin-orbital splitting. The intensity of the band was reduced. The absorption band at 388 nm increased in intensity, with the formation of many peaks on third addition of the reagent. The reason for these peaks is not clear at the moment, although this can be a sign of a decrease in symmetry such that spin-orbital coupling has increased.

The specific wavelengths of the absorption band for Co(III) for the transition  $^1A_{1g} \rightarrow ^1T_{2g}$  are given in Table 4, along with the corresponding molar absorptivity. The assignment of this band is based on the spectra of Co(III) complexes reported in other studies (3, 16, 25) and also in the assignment of transitions in  $d^6$  tetrahedral complexes as discussed by Schlaefer and Gliemann (24).

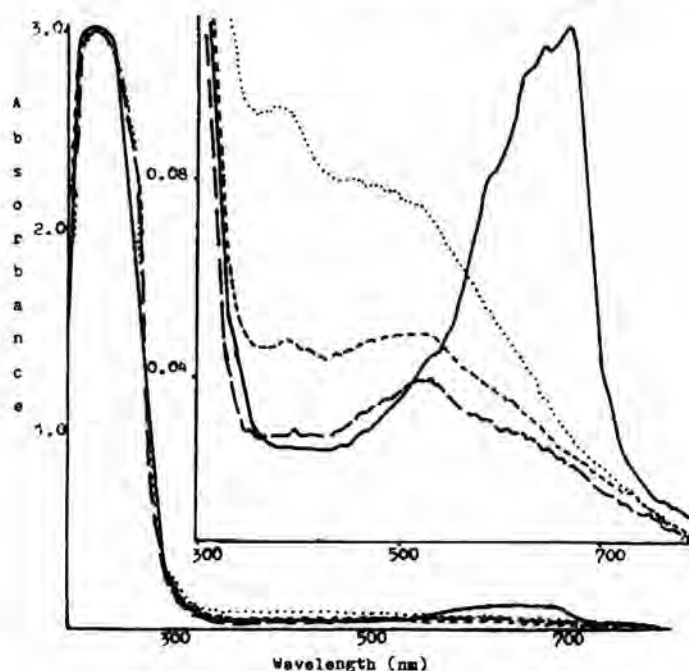


Figure 9. The absorption spectrum of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  ethanol (0.001 M (—)), upon addition of 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  to 3.0 mL of complex, 0.04 mL (— — —), 0.08 mL (— · — · —), 0.12 mL (· · · · ·). The inset is a magnified absorption spectrum in the visible region..

Table 4. The new absorption band which appeared upon the addition of 0.12 mL, 0.001M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  to 3.0 mL of 0.001 M solution of complex in the corresponding solvent.

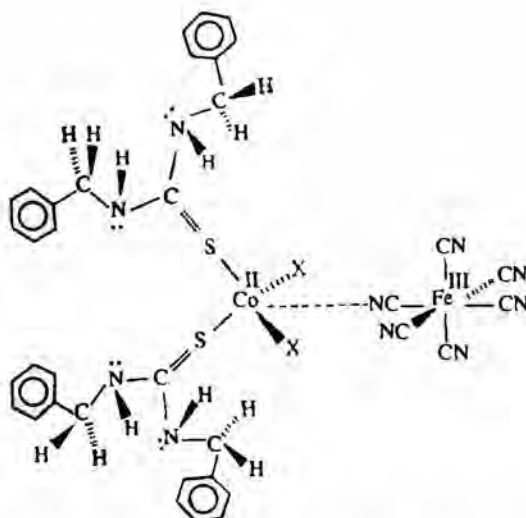
Solvent	Wavelength, nm (molar absorptivity)	
	$[\text{Co}(\text{Dibenztu})_2\text{Cl}_2]$	$[\text{Co}(\text{Dibenztu})_2\text{Br}_2]$
Acetone	372(68)	372(70)
Acetonitrile	388(112)	388(132)
Ethanol	384(70) 476(65)	376(95) 456(80)

It is to be noted that the molar absorptivities of the intermediate of the bromide complexes were higher than those of chloride analog. Furthermore, the absorption band for the ethanolic solution was shifted to higher wavelengths for the bromide complex, compared to the corresponding bands for  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$ .

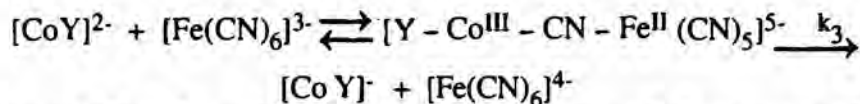
Another interesting change in the absorption spectra of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  and  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  in the three solvents is the behavior of the halide to metal

charge transfer band at around 300 nm upon the addition of  $[\text{Fe}(\text{CN})_6]^{3-}$ . The changes are summarized in Table 5.

The charge-transfer band of the complex is intensified by the polarity of the solvent. Upon addition of the oxidant, the charge-transfer even increases in intensity, along with the aromatic band, if the solvent is polar. This is detectable in the ethanolic solution of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  and  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$ . This can mean that the transfer of the electron affects the chloride. This is understandable from the configuration of the complex. The approach of the  $[\text{Fe}(\text{CN})_6]^{3-}$  can only be through the side of the halide ligands since the other side is blocked by the bulky dibenzylthiourea ligands, as the following illustration shows:



**The Formation and Decomposition of a Reaction Intermediate.** The formation of a cyanide-bridged intermediate between  $[\text{CoY}]^{2-}$  and  $[\text{Fe}(\text{CN})_6]^{3-}$  has been reported by Huchital and Hodges (26) to be the path of the following reaction:



Where Y stands for 1,2-cyclohexanediamine tetraacetate. In later reports, Huchital and Lepore (27) and Rosenheim, Speiser, and Haim (19) had shown that the reduction of hexacyanoferrate(III) ion  $[\text{Fe}(\text{CN})_6]^{3-}$  by ethylenediaminetetraacetatocobaltate(II),  $[\text{CoEDTA}]^{2-}$  proceed via the following mechanism:

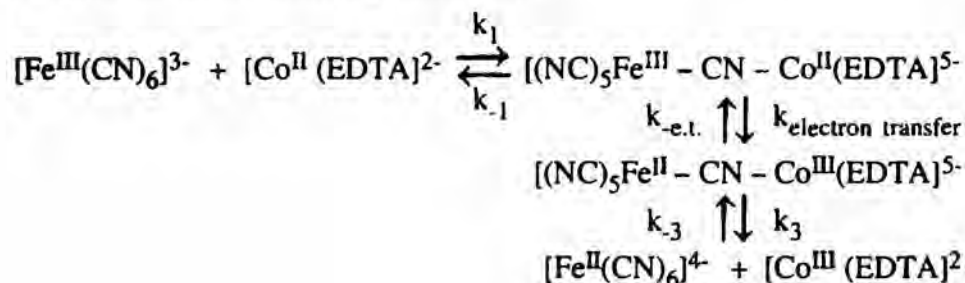


Table 5. Changes of the halide  $\rightarrow$  metal charge-transfer band upon the addition of oxidant to the solution.

Charge-transfer band present in original complex		Charge transfer-band not present in original complex nor upon addition
Disappeared upon addition of reagent	Still present/ increased upon addition of reagent	
[Co(dibenztu) <sub>2</sub> Cl <sub>2</sub> ] in acetone		
[Co(dibenztu) <sub>2</sub> Br <sub>2</sub> ] in acetone		
[Co(dibenztu) <sub>2</sub> Cl <sub>2</sub> ] in acetonitrile	[Co(dibenztu) <sub>2</sub> Br <sub>2</sub> ] in acetonitrile	
	[Co(dibenztu) <sub>2</sub> Br <sub>2</sub> ] in ethanol	[Co(dibenztu) <sub>2</sub> Br <sub>2</sub> ] in ethanol

The bridged intermediate, [L-Fe(III)-CN-Co(III)-L], can be made stable depending on the other ligands in Co(III). Reagor et al. (16) reported that with *N*-hydroxyethylEDTA and *N*-benzylEDTA, the binuclear bridged species can be stored at room temperature indefinitely without detectable decomposition.

The studies just mentioned were carried out in aqueous solutions. In the present study which is carried out in nonaqueous solvents, the existence of the bridged intermediate in reactions of tetrahedral Co(II) complexes with [Fe(CN)<sub>6</sub>]<sup>3-</sup> is evident from the appearance of new absorption bands. The change of absorbance of the solution of the complex upon addition of the reagent was added, was monitored.

There are three possible behaviors of the bridged intermediate: first, when at least one of the product ions is substitution labile, the decay of the successor binuclear complex is very rapid; second, the bridged complex decomposes slowly – this happens when an inner-sphere redox reaction, for example, occurs between two complexes in which both product metal centers are substitution inert and in addition, one of the metal ions is complexed with a multidentate ligand; third, both the product ions are substitution inert such that the cyano-bridged species can be extremely stable.

The stability of the intermediate found in this study appears to depend on the solvent used, and the partner ion in the complex. Kinetic studies were carried out by reacting 3.0 mL of 0.001 M  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile and of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetone and in acetonitrile, with 0.04 mL, 0.08 mL, 0.12 mL of aqueous 0.001M  $\text{K}_3[\text{Fe}(\text{CN})_6]$  solution. Figure 10 shows the changes in the absorbance of the solutions of cobalt(II) complex plus the reagent at 390 nm. In most cases, the formation of an absorbing species is evident from the increase in absorbance; the decay of this species into a stable moiety is also evident from the decrease in absorbance.

The increase in absorbance when  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetone reacted with 0.04 mL of the oxidant (Figure 10) indicates that formation of an intermediate spe-

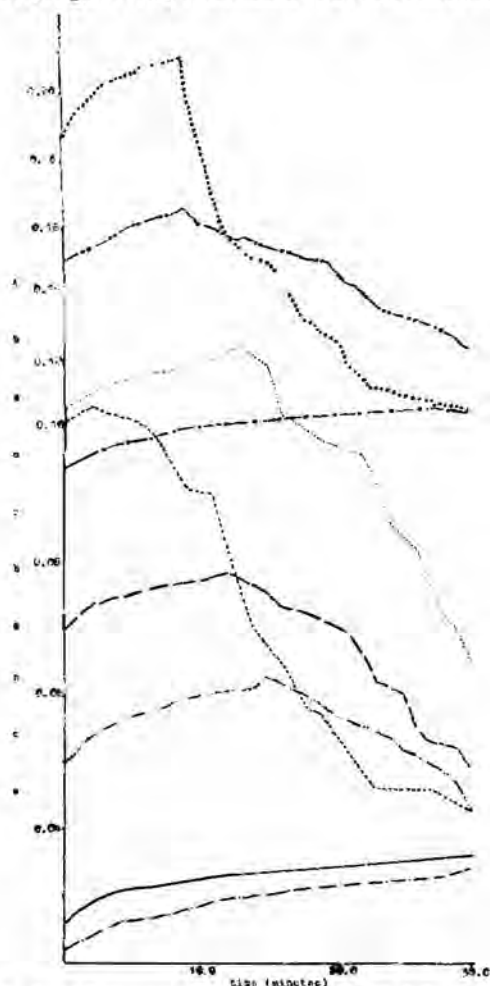


Figure 10. Change of absorbance of 3.00 ml 0.001 M of complex with time upon addition of 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$ :  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetone, 0.04 mL oxidant (—), 0.08 mL (— —), 0.12 mL (— — —),  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  in acetone, 0.04 mL oxidant, (— . — .), 0.08 mL (— ... —), 0.12 mL (.....);  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile, 0.04 mL oxidant (— . — .), (— .. — ..), 0.12 mL (.....).

cies is still going on at the time the absorbances were measured. However, upon addition of more reagent, the formation of the intermediate is completed earlier, at 12 and 2 min for 0.04 and 0.08 mL respectively and a subsequent decay of the intermediate species is observed.

As illustrated in Figure 10, an increase of absorbance occurred when  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  in acetone reacted with 0.04 mL of the oxidant. When additional reagent was added, the times needed for the completion of the formation of the intermediate are 15 and 13 minutes for 0.08 and 0.12 mL respectively. These are longer compared to the reaction of the chloride analog in the same solvent.

It is to be noted that the decomposition of the intermediate appears to proceed in steps, as evident in the periodic humps of the absorbances of the solution to which 0.12 mL of the oxidant has been added. This will be the subject of a separate study later.

### CALCULATION OF RATE CONSTANTS

All reactions were carried out under pseudo-first order conditions with Co(II) complexes in large excess over the oxidant, aqueous  $\text{K}_3[\text{Fe}(\text{CN})_6]$ , at room temperature. Reactions were observed at 390 nm. The  $\log(A_t - A_\infty)$  for the reaction  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile and 0.08 mL of aqueous  $\text{K}_3[\text{Fe}(\text{CN})_6]$  where  $A_t$  and  $A_\infty$  are the absorbances at time  $t$  and after 10 min after mixing respectively, are plotted vs time. Figures 11 and 12 show the resulting graph of the rate constants of

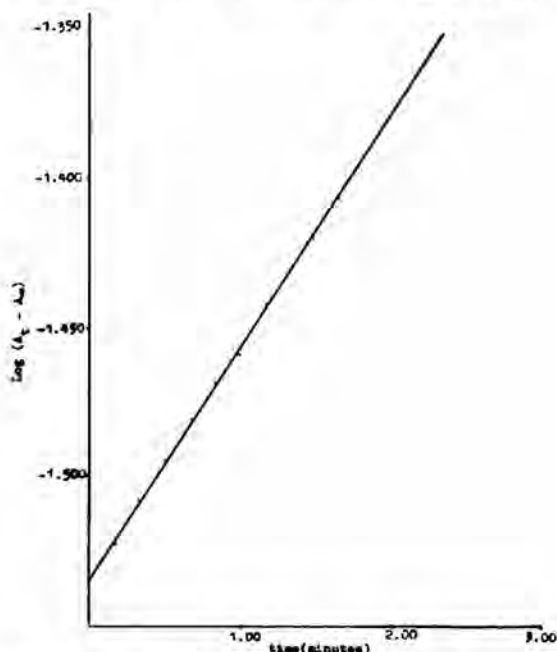


Figure 11. Apparent rate constant of formation of the intermediate, 3.00 mL 0.01 M  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile plus 0.08 mL 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$ .  $A_t$  is the absorbance at time  $t$ ;  $A_\infty$  is the absorbance after 10 minutes.

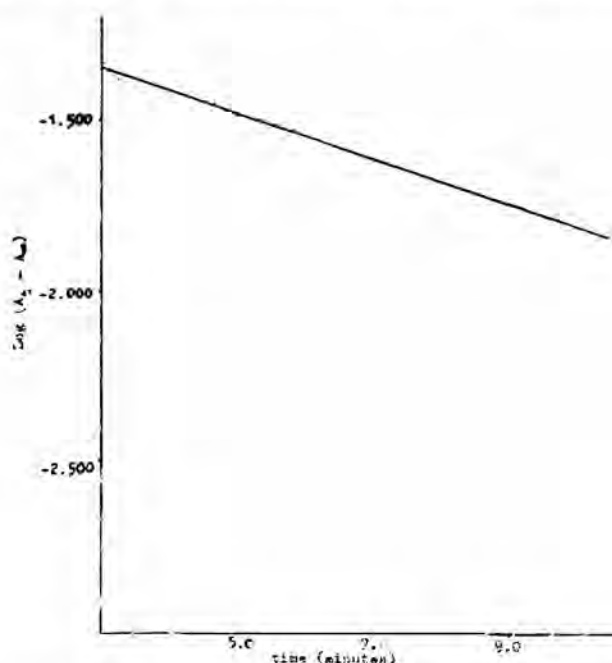


Figure 12. Apparent rate constant of formation of the intermediate, 3.00 mL 0.01 M  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  in acetonitrile plus 0.08 mL 0.001 M  $\text{K}_3[\text{Fe}(\text{CN})_6]$ .  $A_t$  is the absorbance at time  $t$ ;  $A_\infty$  is the absorbance after 10 minutes.

formation and of decomposition of an intermediate species, respectively. The rate constants were determined as the linear slopes of plots of  $\log(A_t - A_\infty)$  vs time. Based on the plots, the apparent rate constant of intermediate formation (Figure 11) is  $7.81 \times 10^{-2} \text{ min}^{-1}$  or  $1.3 \times 10^{-3} \text{ sec}^{-1}$ . The apparent rate constant of intermediate decomposition is  $1.72 \times 10^{-2} \text{ min}^{-1}$  or  $2.87 \times 10^{-4} \text{ sec}^{-1}$ .

Thus the reaction of  $[\text{Co}(\text{dibenztu})_2\text{Cl}_2]$  and of  $[\text{Co}(\text{dibenztu})_2\text{Br}_2]$  solutions in acetone, in acetonitrile, and in ethanol, with the aqueous oxidant  $\text{K}_3[\text{Fe}(\text{CN})_6]$  involves an inner-sphere mechanism of electron transfer as evident in the formation of a bridged intermediate.

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## ***SOCIAL SCIENCES DIVISION***

### **SCIENCE & TECHNOLOGY AND HIGHER EDUCATION FOR PEACE AND DEVELOPMENT IN MINDANAO**

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#### **ABSTRACT**

Development activities are intensifying in Mindanao ushered by direct trade and economic links between Brunei, Indonesia, Malaysia, and the Philippines which constitute the BIMP in the East ASEAN Growth Area (EAGA). Complementing government efforts, the Mindanaoans' peace and development initiatives gave rise to the Mindanao Agenda for Peace and Development (MAPD) which will give direction to development efforts assuring Mindanaoans as beneficiaries of the fruits of development.

The higher education sector, under the leadership of the Commission on Higher Education (CHED) will play a significant role in harnessing and focusing S&T for the utilization of resources and the protection of the environment. The higher education sector faces with enthusiasm the challenges and the opportunities brought about by the development activities in the island. Development plans and programs emphasizing excellence, relevance, cultural diversity, S&T, the environment, and a culture of peace are being laid down, which augur well for Mindanao. CHED gives priority to Mindanao and will support the establishment of centers of excellence and priority programs in S&T and peace studies. Mindanao is, thus, fortunate to have a number of HEIs eager and willing to work together to tap the synergy in cooperation and complementation between and among themselves for the benefit of the island. Pursued with all seriousness and dedication, the vision of Mindanao as a land of promise and prosperity will be a concrete reality.

#### **INTRODUCTION**

At present, despite the prevailing peace and order situation, Mindanao contributes substantially to the Philippine economy. Definitely, it will play a major role

in the realization of the vision of a Philippines 2000. Recognizing this, the present administration is strategically maneuvering to effect this.

The Philippines entered into direct trade and economic links with its southern neighbors. Now, Brunei, Indonesia, Malaysia, and the Philippines constitute the economic tetrad **BIMP**. They are the vertices of the emerging growth quadrangle in this side of the Pacific rim aptly referred to as the East ASEAN Growth Area (**EAGA**). Known as the regional cross-border cooperation, the **BIMP-EAGA** initiatives identified the following areas of cooperation: **air and sea transport, tourism, and fisheries** and expects to increase not only tourism but also trade and investments in the area.

The EAGA Project, a major policy shift of the national government for Mindanao, has created for the island a key role as the country's front door to ASEAN. Also, the government triggered the economic integration of the island through inter-regional infrastructure projects. Complementing government efforts, the Mindanaoans' peace and development initiatives, resulting in a series of fora for consultations and consensus-building, as regards the process and direction of peace and development of Mindanao, and eventually, gradually giving form and substance to the Mindanao Agenda for Peace and Development (**MAPD**), can be considered a phenomenon. With government and the people working together, the vision will surely become a reality.

Rich in resources, Mindanao is a strong base that will support development programs and structures that will rise in this part of the globe.

### THE RESOURCE BASE OF MINDANAO

Mindanao is the second largest island in the Philippines with a land area of 102,043 square kilometers, which is 34% of the country's total. It is home to 16 million (1994) people which is about 25% of the country's total population.

Largely underdeveloped, the Mindanao economy rests heavily on its agricultural, fishery, and forest resources sustained by the island's fertile soil, favorable climate, and abundant water resources. Of the country's total agricultural production, it is estimated that the island contributes 36%. It supplies 67%, 62%, and 23% of the country's corn, coconut, and palay, respectively. The country's export of banana, natural rubber, and pineapple comes mainly from this island. Producing pomelo, mangosteen, and durian, it is also suitable for growing cotton, abaca, ramie, and other fibers. Teeming with a variety of fish species, 33% of all fish caught in the Philippines come from Mindanao. Also, it shares 42% of the country's total fish volume from aquaculture. Rich in metallic minerals, its gold and nickel deposits are, respectively, 48% and 63% of the national reserves. Other mineral deposits including aluminous laterite, lead, zinc, manganese, mercury, and molybdenum account for 86% for the country's total. Its 37.5 million metric tons of coal is 18% of national reserves. And the potential of Mindanao having significant oil reserves is high. Energy for hydroelectric and geothermal power generation is abundant. Thus, power for home and industry needs is cheaply available.

But the most important resource of Mindanao is its people – young, dynamic, culturally diverse, and known throughout the island's colorful history and traditions.

Prudent development in these sectors, both in the natural and in the human resource sectors, enabled in an atmosphere of peace currently being pursued by the Mindanao people, will be the steps needed in the eventual eradication of poverty in Mindanao and the gentle push for its sustained development. With activities having started and gaining momentum, the people of Mindanao have also taken the initiative to be involved and thus be assured of being beneficiaries of the fruits of development.

### **THE MINDANAO AGENDA FOR PEACE AND DEVELOPMENT**

Development activities, brought about by the BIMP-EAGA are intensifying and the signs of an economic turnaround are becoming increasingly more visible. Mindanao's export performance showed dramatic growth and direct foreign investments more than doubled.

Left on its own, however, development could proceed even side by side with poverty, if not actually causing it, generating conditions that threaten peace. To steer development in the right direction a comprehensive peace process is being pursued and carried out in Mindanao. This ongoing peace process resulted in the formulation of the Mindanao Agenda for Peace and Development.

This Agenda embodies the vision of the people of Mindanao for peace and development and articulates the strategies for concretizing this vision. It is drawn from existing frameworks for peace and development at the national and local levels such as the Comprehensive Peace Process, the Social Reform Agenda (SRA), Framework for Human and Ecological Security (HES), Mindanao 2000, and the Mindanao Framework Development Plan. Formulation of the agenda also took into account the National Unification Commission (NUC)'s nationwide public consultation, the First and Second Mindanao Peace and Development Summits, and other local consultations. An evolving document, it is going through a consensus-building process. Thus far, the summit process has resulted in the identification of principles and thrusts for the MPAD as well as preliminary listing/identification of strategies/programs for the agenda. Thus, it is an agenda that articulates the major concerns of all sectors, faiths, and cultures in the area.

With due emphasis it gives to peace and order, unity and teamwork, responsible government, and people-centered development, it sets the preconditions for carrying out development efforts in Mindanao.

### **HIGHER EDUCATION IN MINDANAO**

In the wake of all these developments, a lot of challenges and opportunities are opened to us, as individuals and collectively as a nation. To take full advantage

of these opportunities brought about by economic and trade relations with our neighbors, as a nation we must be globally competitive. For a nation to be globally competitive, its citizens individually must be empowered. This empowerment is made possible through education.

During the first Mindanao Educators Congress, held last year (1995), Mr. Paul G. Dominguez of the Office of the President–Mindanao highlighted that one big opportunity for Mindanao educators is to “help build unity and teamwork in Mindanao” and he specified six of these immediate concerns:

1. Full participation of educators in the development process at the:
  - Local level
  - Area development zone level
  - Mindanao-wide level
2. Human resource development through formal and non-formal education
3. Creating a forum for dialogue and understanding among Mindanaoans through schools
4. Encouraging community involvement in local governance through:
  - Project monitoring
  - Encouraging transparency in government
5. Communicating results of Mindanao’s development through the students
6. Building a *Culture of Peace*, especially among the youth

Moreover, he added that the goals set in Mindanao 2000 plan for the island are:

- Global competitiveness
- Internal and external integration
- Sustainability
- People-centered development

From these, the significant role higher education will play is obvious.

In another paper, “**Higher Education in Mindanao: Towards Making Mindanaoans Globally Competitive**”, presented during the First Mindanao Educators Congress, CHED Chairman Angel C. Alcala mentioned that the Commission on Higher Education (CHED) has completed, through collaborative and participative sectoral planning with all stakeholders in higher education in Mindanao, the Ten-Year Higher Education Development Plan which covers the period 1996-2005. This blueprint embodies policies and strategies that are aimed at addressing sector-wide concerns on quality and excellence; access and equity; relevance and responsiveness; and efficiency and effectiveness.

Consistent with the above ten-year development plan, and cognizant of the need to boost the nation’s capacity to respond to the demands of the regional cross-border cooperation, Chairman Alcala, for and in behalf of the Commission, presented in the said Congress a Five-Point capacity-building agenda for Mindanao with the aim of actualizing the empowerment and global competitiveness of Mindanaoans, through higher education.

These five items in the agenda are:

**1. The Commission will encourage higher educational institutions, both public and private, to focus on such disciplines that provide the competency/expertise needs of the Mindanaoans to enable them to contribute to the success of the BIMP-EAGA.**

Areas of cooperation identified in the BIMP-EAGA initiatives are, to reiterate, air and sea transport, tourism, and fisheries. The consequent institutional focusing, however, will depend on the institutions' demonstrated capability to offer such critical courses with excellence. The Commission will give assistance to responding institutions. To this end the Commission is developing a plan for higher education development geared to the potentials for Science and Technology.

**2. The Commission will encourage innovations.**

These innovations referred to are those intended to make the curricula genuinely responsive in equipping our graduates with the expertise or competencies required by the labor market and to those which will enable them to engage in productive endeavors such as entrepreneurship considering the vast opportunities eventually arising from the BIMP-EAGA initiatives. Curricular innovations for responsiveness and relevance will be encouraged and supported by the Commission.

**3. The Commission promotes the strengthening of graduate education and research.**

Graduate education will play a much bigger and much more responsible role in enhancing Mindanao's capacity to the BIMP-EAGA challenges. There exist potentials of graduate education in producing highly specialized and capable human resource to man key positions in the areas of cooperation identified in the growth area. Graduate research can actually play a major role in preparing not only the requisite expertise for the BIMP-EAGA but it can also open up frontiers for further economic development and cooperation. Graduate education and research will lead to the honing of skills and competencies needed to generate knowledge for both instruction and application not only within the confines of the academe but more importantly in the communities where these higher education institutions are located.

**4. The Commission encourages complementation between and among institutions, both public and private, in areas such as faculty upgrading, facilities development, instruction, research, and extension.**

If there is one single challenge the country has to face, it is how quickly it can respond to the demands and requirements of EAGA. The synergy arising from complementation will aid greatly in providing the pool of highly competent human resources for the BIMP-EAGA.

**5. The Commission will make available resources to insure that these five-point agenda is carried out, specifically, scholarships and research grants for students and faculty.**

**Other resources will be tapped to support special initiatives and/or programs that are aimed at enhancing the national capacity to respond successfully to the challenges posed by the regional cross-border cooperation, or the BIMP-EAGA initiatives.**

Thus, higher education, with its three dynamically interacting aspects of learning, applying, and generating knowledge has a very important role to play in the development of Mindanao.

### **SCIENCE & TECHNOLOGY FOR MINDANAO**

For material progress, S&T is indispensable. It will be used/applied by people on resources to produce man's material needs. It will greatly be used to respond to the demands and challenges arising from the BIMP-EAGA initiatives. All these developments, projects, and activities will affect the people of Mindanao.

Considering that not a few projects in the past have been carried out which did not directly benefit the majority, now at least, development efforts could be pointed in the right direction. The MAPD serves as the blueprint for the development plan. S&T could then be focused on priority development projects responsive to community needs. While S&T will be utilized for the processing and utilization of natural resources, S&T will likewise be used in the protection and enhancement of the environment that provides these resources, and where possible to reverse the harm that has been done.

Review of the MAPD will show that embodied in the agenda are twelve general thrusts. Two, among the thrusts, can be considered directly under the concern of S&T. One of these is:

**Advocate sustainable development based on cultural, ecological, and biological diversity, with the following items as among its programs/projects:**

1. Increase production and intensify propagation of organic fertilizers and herbal products
2. Use environment-friendly technology
3. Install waste management systems especially for industry and urban centers
4. Install pollution abatement devices for industries
5. Speed up diversified fish farming projects along all viable seacoasts and bays in Mindanao and its inland communities; make immediately available "multi-crop" fish farming technology by the Department of Agriculture

And the other is:

**Implement relevant and culture sensitive education, with the following programs/projects, among others:**

1. Establish an ASEAN Science and Technology University (Bukidnon-Davao-Agusan Area)
2. Provide manpower skills and entrepreneurial training
3. Provide more scholarships for Mindanaoans especially in ARMM

Focused, S&T can help greatly in making these needed production systems effective and efficient. This will result in higher productivity and increases in production. Present systems could be further improved/enhanced. Others could be made, to be at least, sustainable. Newer systems could be improved to accelerate attainment of production capacities at the same time enjoy high productivities. For the purpose, existing packages of technologies could be adapted to specific planes of use. Sometimes, only a fine tuning of the technology is required. At other times, major improvisations are needed in the adaptation of a specific technology. For the still untapped resources of Mindanao, basic research may be undertaken.

In the focusing of S&T for Mindanao some considerations are necessary as spelled out in the Agenda. One consideration is that the technologies to be used must be environment-friendly. Or there must be instituted pollution-abatement technologies where needed. Another important consideration is that these technologies must not be incompatible with the culture of the people who will use them. Thus, village-level technologies must be promoted. Labor displacing technologies must be avoided whenever possible.

Beyond science and technology, however, education encompasses a vast universe of human concerns. It is also concerned with ethics, human values, and a myriad of other things regarding man and his relation with those of his kind and his environment.

Aware of these developments – BIMP-EAGA initiatives, the MAPD and preceding plans, the Long-Term Higher Education Development Plan – various elements in the higher education sector, viz., educators and state and private colleges and universities, welcome with enthusiasm all the concomitant challenges and opportunities and propose programs of actions and/or offer suggestions on how the higher education sector can best respond in attaining and sustaining the peace and development efforts in the island of Mindanao.

## **MINDANAO ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES**

As public-financed institutions, the Mindanao SUCs are expected to join the mainstream of development efforts for Mindanao.

During the General Assembly meeting of the Mindanao Association of State Colleges and Universities held at Bukidnon State College, Bukidnon on 27-29 No-



vember 1995, a draft paper entitled "Mindanao SUCs Higher Education Long-term Development Plan: 1995-2020", was presented.

In the paper, Dr. Prantilla laid the strategic response of the Mindanao SUCs to the development needs of the island, seeing that their support will be in the form of:

1. **Appropriate manpower outputs of the SUCs**
2. **Generation of new technology to enhance productivity and raise the standard of living of the population**
3. **Close working relationships between the Mindanao SUCs and government agencies/bodies and between the Mindanao SUCs and the private sector (private companies/business entities, etc.)**

They contend that if they can adequately face the issue and concerns that confront them now, they in effect are doing their part in the development of Mindanao. The SUCs, in general, face the following issues and concerns:

1. **Low quality of higher education**
2. **Lack of/inadequate linkage between the SUCs and industry**
3. **Inadequate complementation and networking among the SUCs**
4. **Inadequate budgetary allocation/financial resources**
5. **Networking with private higher education**

All the SUCs of Mindanao have agreed between and among themselves to enter into cooperation and complementation arrangements which will enable them to effectively respond and participate in the development of Mindanao.

The following are considered by the Mindanao SUCs as flagship programs, quality and excellence in which will lead to the region's global competitiveness in view of Mindanao 2000 and the BIMP-EAGA initiatives:

**Basic Sciences, Material Science, Fisheries, Forestry, Crop Science, Animal Science, Engineering, Oceanography, Marine Sciences, Geo-science, Information Technology, Environmental Science, Social Work, Industrial Education, Teacher Education, Food Technology, Medical Science, Development Communication, Veterinary Medicine, Plantation and Crop Sciences, Horticulture, Agricultural Technology, Agribusiness.**

#### **MINDANAO COLLEGES AND UNIVERSITIES SCIENCE CONSORTIUM**

A group of tertiary institutions in Mindanao, composed of five state universities in Mindanao and six accredited private universities and colleges, that are lead institutions in their respective regions, came together to form the Mindanao Colleges and Universities Science Consortium (MCUSC), in recognition of the vital role that Mindanao, immersed in the developments arising from the BIMP-EAGA initiatives, will play in consonance with the country's aim of being a Newly Industrializing Country (NIC) by year 2000.

The consortium proposes to assume a leading role in cooperation with CHED and DOST in an island and system-wide concerted effort to increase the number of trained science, mathematics, and technology teachers in Mindanao. Considering that under the Science and Technology Master Plan (STMP) the learners in science and mathematics constitute the most important sector in the country's effort to achieve NIC status by year 2000, current efforts at producing the needed teachers have to be augmented.

Thus, the MSUSC proposes, initially, the following:

1. **To upgrade the qualifications of the faculty of the member institutions in the breeder sciences, engineering science, and technology**
2. **To upgrade the qualifications of the faculty of its feeder secondary schools through the offering of undergraduate and graduate (MAT, MST, MAEd, major in the breeder science) courses**
3. **To undertake an island-wide inventory of science and technology resources (facilities and manpower)**

#### **MINDANAO GRADUATE EDUCATION PROGRAM**

Considering that the development of the education sector is viewed as one of the potent forces that will shape the future of this island, as it pursues its goals of peace and development, a Mindanao Graduate Education Program is being conceptualized in the Commission on Higher Education.

Reasons cited for the critical need of developing higher education in Mindanao are the following:

1. **Absence of highly trained manpower at the master's and doctoral levels, particularly in Science and Technology;**
2. **Lack of facilities, equipment, and infrastructure to fully support a well-developed scientific community; and**
3. **Absence of research opportunities and academic exchanges among the few scientists in Mindanao thus forcing them to migrate to Luzon.**

In the proposed program, it was noted that although staff development opportunities had been provided in the past, notably by the DOST, the distance of Mindanao from the educational centers in the country negated these efforts.

Project objectives are enumerated as follows:

1. **To identify key graduate centers in Mindanao where S&T Programs and peace studies may be developed in support of the national socio-economic blueprint in this part of the country**
2. **To provide financial and technical assistance to these graduate centers over a period of five years**

Graduate centers will be identified to develop the following priority programs:

1. Basic sciences
2. Materials science
3. Volcanology and thermal energy
4. Mining and geology
5. Mathematics and information technology
6. Agribusiness
7. Marine science, fisheries, oceanography
8. Peace studies.

Since resources are not unlimited, and for efficiency, the centers shall be developed using the consortium approach.

### **CURRICULUM RELEVANT TO MINDANAO**

In his paper, apparently elicited by the ongoing development frenzy in the island, and the anticipated prospects, Fr. Eliseo R. Mercado, Jr., OMI stresses that "the key to these new opportunities is the crucial issue of peace ... As a matter of fact, the path to Mindanao's prosperity being when its multiethnic peoples identify themselves as one community sharing the same dreams and working together to attain a common goal". In line with these, according to him, in the higher education sector, vital characteristics, among others of a curriculum relevant for Mindanao are:

1. **Recognizes and respects our diverse multi-ethnic cultures and beliefs**
2. **Nourishes, promotes, and advocates a culture of peace that is community-based, participative, and consultative**
3. **Recognizes the oneness of the people and their environment**

According to Dr. Erdulfo B. Fernando, in "Relevant Teaching Training, Pre-service and In-service Education for Mindanao 2000", among the needs that surfaced in the consultations on education is the spiritual development of the student to make him a God-fearing, peace-loving citizen of the nation. The people of Mindanao want to include in their curriculum the teaching of religion.

He said that a school system characterized by quality would enable a graduate to cope with life in his environment. Without neglecting the development of scientific, technological, and vocational efficiency, it takes into consideration the culture, tradition, religion, and economy of the people.

Thus, a relevant curriculum is one that accepts cultural diversity, gives due importance to the inculcation of human values, and promotes a culture of peace. It allows us to be masters not only of the environment and its resources, but also of ourselves and our relationship with one another.

## **UP IN MINDANAO**

Newly established in Mindanao, and viewing the development in the region in proper perspective, it sees the appropriate roles it will play. Its establishment is indeed, remarkably, timely. It will produce people trained in agri-processing, engineering, environment sustainability, and social science.

Strategically involved in Mindanao's participation in the EAGA, research and technical training will focus on the processing of raw materials abundant in the region. From mere exporter of raw foods, the Philippines can, thus, shift to exporting processed foods.

Management of the region's vast natural resources which include the virgin forests, the marine waters and its inhabitants, and other land and water resources is an important role the University will assume. Considering that thirty percent of the total protected forest area in the Philippines is in Mindanao, UP will provide expertise in forest management with projects which will showcase biodiversity, social forestry, and eco-tourism.

UP can also contribute to the vital and urgent concern of bringing peace in the region, acting as agent of integration of the various tribes. Also it can look into the important role women can play in the peace process and other related concerns.

Aside from helping in the development of entrepreneurial skills in the island, it could also help in the strengthening of cooperativism.

## **MINDANAO STATE UNIVERSIT**

The Mindanao State University is an institution of higher learning whose existence was justified by a unique social purpose. Created in 1957, its noble purpose is to promote the social and economic well-being of Mindanao, especially the indigenous communities there, while at the same time speeding up the integration of the Muslims and other cultural "minorities" into the mainstream of Philippine social and political life.

At present Mindanao State University has grown far and wide and has 7 autonomous campuses distributed all over Mindanao, Sulu, and Tawi-Tawi offering almost three hundred programs, including graduate courses, for over 17,000 students. The campus network includes MSU Marawi, MSU Iligan, MSU Maguindanao, MSU Naawan, MSU General Santos, MSU Sulu, and MSU Tawi-Tawi. Over the years, all these campuses of the University have produced over 25,000 graduates, many of whom now occupy top positions in the government and private sectors.

Mindanao State University strives to be the premier supra-regional university geared towards the agroindustrial, ecological, socio-economic, and political development of Mindanao. It aspires to establish centers of excellence in science, technology, business, humanities, social sciences, and related fields. It will set the standards of excellence and serve as the training ground for future leaders of the various sectors of society.

Within the framework of the government's Philippines 2000, the University envisions a prosperous Mindanao during the same period with highly motivated, self-reliant, culturally diverse but unified communities. It aims to make these communities socioeconomically and politically dynamic by providing them ample and appropriate opportunities for self-fulfillment within a framework of ecological soundness, sustainable development, and equitable growth .

### **REMARKS**

Making S&T, in proper focus, work for Mindanao, in consonance with other national programs enabling the attainment of needed social reforms, in an atmosphere of peace and harmony, in a community of people imbued with reverence for man and human values, notwithstanding the diversity in cultures and beliefs, will then lead to the materialization of yesteryears' vision of Mindanao as the Land of Promise.

**THE INTEGRATION OF ISLAMIC DOCTRINES AND  
TEACHINGS WITH SCIENCE SUBJECTS IN MINDANAO  
STATE UNIVERSITY – SCIENCE HIGH SCHOOL:  
STATUS AND PROSPECTS**

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**RATIONALE/BACKGROUND**

This study was conducted to determine the extent of integration of Islamic doctrines and teachings in the science subjects and the extent of benefits that could be derived in the integration of Islamic doctrines and teachings in the science subjects. The findings will serve as basis for the people involved in the development of a Science High School Curriculum.

**CONCEPTUAL FRAMEWORK**

There are several concepts which have been premised is Article XIV Section 3 of the 1987 New Philippine Constitution by Hector de Leon which underscores specifically that:

... education shall teach the rights and duties of citizenship, strengthen ethical and spiritual values, develop moral character and personal discipline, encourage critical and creative thinking, broaden scientific and technological knowledge and promote vocational efficiency.

It is therefore in line with the aforementioned mandate that moral and spiritual values should be enhanced which will be possible where Islamic doctrines and teachings are taught. Doing this also broadens scientific knowledge in the sense that the integration will be done precisely in all subjects especially those in science.

A concept by Metcalf et al. (1990) regarding the role of a curriculum motivated the present study. "... a curriculum should assist young people in the examination of their basic assumptions about society and its improvements must deal with values and social politics".

The aforementioned idea looks upon the curriculum as a vehicle for creating impressions upon the youth on the impact of society in their lives. It expects the course of study to spearhead improvements in society where values-formation must be among its projects.

Science education develops science and technology literate citizens who are imbued with PRIDE which connotes: Productive, Relevance, Integrity, Discipline, and Excellence. Investment in education, foremost in Science Education, aims to equip the individual to become productive and resourceful; solves problems logically, and find ways to maximize the use of available resources for a profitable end.

In view of the foregoing, it is felt that Islamic doctrines and teachings abiding with PRIDE dovetail with the goals of Science and Technology Education Plan (STEP), that is for the Philippines 2000.

Thus the resolution adopted by the Science and Technology Coordinating Council (STCC) 1993, in part states that: "Whereas, the objectives of the Plans are: (1) to develop a scientifically and technologically literate citizenry; and (2) to accelerate the development of Science and Technology manpower needed for social and economic growth".

An analysis of the contents of the science subjects discloses, that there are few or insufficient materials that could guide the students to be morally and spiritually upright, conscious of the need to seek Divine Guidance through their lives. Moreover, there are teachers who are not prepared to use such materials.

An exposition on the science curriculum by Varela (1971) further inspired this study:

It advocated:

"Science is better transmitted when structured around interdisciplinary themes. Educational curricula have to take cognizance of science and its advances because it is a very relevant segment of our culture. It is through this badge of relevance that concepts and skills, values, and knowledge are accepted by our younger brethren. There is a need therefore to relate course material to the background of the particular students in the course."

As pointed out in the foregoing quotation, it is explicit that the science curriculum by itself, because of its unceasing advances, has found the need to accept the infusion of interdisciplinary disciplines to suit the demands of different sectors of society. It is in this context that it is perceived that the students in Mindanao State University have a need to be exposed to the doctrines and teachings of Allah, projecting the science concepts in said teachings.

The current investigation is perceived to be an answer to the suggestion in the aforesaid quotation that course material should be related "to the background of the particular students in the course." The fact that Muslims form part of the minorities in Philippine society should not be taken to mean that they should be deprived of the privilege of being recipients of improved curricular offerings for their own advancement.

With the aforecited ideas and concepts supporting present inquiry, beneficial results can be expected. The paradigm of the study is found in Figure 1. The figure shows a high school student in the center of an inner circle surrounded by the contents of every subject in the science curriculum of the Mindanao State University High School Department.

The outer circle represents the integration of different Islamic doctrines and teachings proposed to be integrated in the science curriculum and are represented by the arrows pointing to the science curriculum. The arrows from the Islamic doctrines and teachings extend passing both the supra system and science curriculum to the high school student since he will be the direct recipient of the contents of the modified course description, which make up the science curriculum.

On the other hand, in the course of teaching-learning situations the student interacts with the teacher for the identification of the Islamic doctrines, affecting his life, eventually transforming the student to become scientifically and technologically literate, morally and spiritually upright.

## **STATEMENT OF THE PROBLEM**

### **Major Problem**

The study intended to determine the extent of integrating Islamic doctrines and teachings with science subjects in Mindanao State University – Science High School in Marawi City.

### **Specific Problem**

Specifically, the research attempted to find answers to the following questions;

1. What are the characteristics of the respondents in terms of age, sex, religion, and educational attainment?
2. What subjects constitute the present curriculum of the Science High School in Mindanao State University?
3. To what extent are Islamic doctrines and teachings integrated in the science subjects in the present curriculum as observed by students and school administrators?
4. How do the reactions of parents and science teachers compare with regard to the possible extent of and possible benefits that could be derived by the integration of Islamic doctrines and teachings?
5. How do the respondents perceive the possible integration in other science subjects of Islamic doctrines and teachings?
6. What are some comments, suggestions, and recommendation of administrators, students, parents, and teachers toward enriching the science curriculum with integrated Islamic doctrines and teachings?



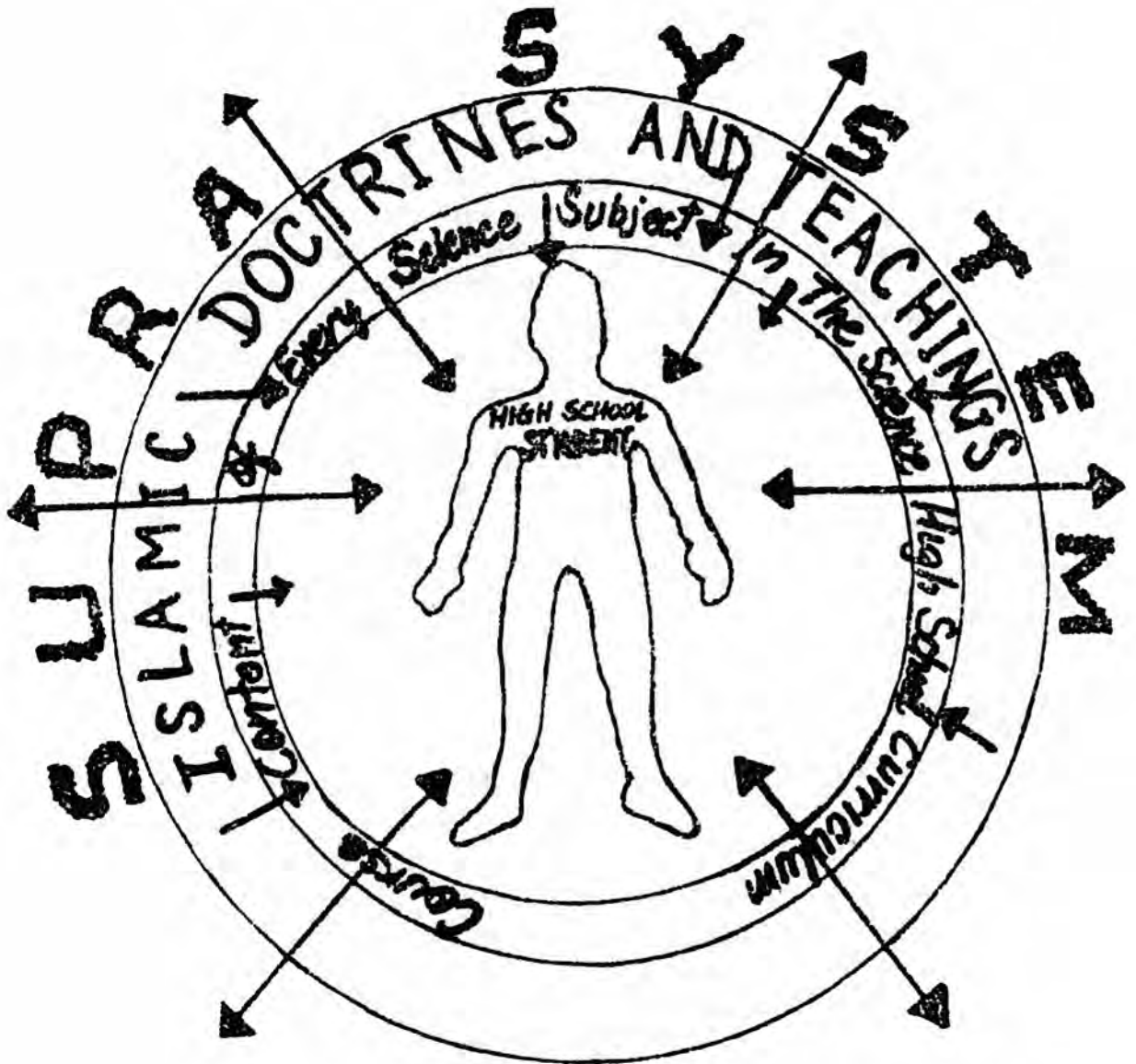


Figure 1. A Paradigm on the Integration of Islamic Doctrines and Teachings with Science Subjects in the Science Curriculum.

## Procedure

The study made use of the descriptive method and anthropological technique coupled with documentary analysis.

The researcher involved all the high school students in Mindanao State University – Science High School from First to Fourth Years. Their parents, science teachers, and some administrators were likewise involved. Table 1 shows the composition of the respondents of the study. Out of the 8 administrators, 7 or 2.0 percent of the total respondents participated in the study. There were 13 teachers who answered the questionnaires. There were 127 parents or 36.5 percent of the total respondents who answered the research instrument. Among the students, 201 or 57.8 percent were involved in the study. It is evident that the students had the greatest participation followed by their parents, their teachers, and least by their school administrators.

A total of 348 respondents were included in the study. Two sets of questionnaires prepared by researchers were administered to them. Interview and observation techniques were also employed. The data were processed at the CEU Center for Data Analysis.

## Treatment of the Data

The gathered data were treated, interpreted, and analyzed using percentage, frequency distribution, sample mean, and t-test.

## Findings

### 1. Profile of the respondents.

1.1 *Age.* Table 2 discloses that the biggest group of student respondents belonged to age bracket 12 to 14 years old. Most of the administrators were between 42 to 44 years old, two were between 45 to 47 years, and 1 was between 30 to 32 years old. The majority of the mentors were just like the administrators, between 42 to 44 years old. A good number were 30 to 32 years old; 2 were 33 to 35 years old, 1 was between 36 to 38 years old, 1 was between 45 to 47 years old and the eldest was 51 to 53 years old.

Table 1. Percentage and Frequency Distribution of the Respondents, N = 348

<i>Type of respondents</i>	<i>F</i>	<i>%</i>
Administrators	7	2.0
Teachers	13	3.7
Parents of students	127	36.5
Students	201	57.8
Total	348	100.0

The great majority of the parents were between 39 to 41 years old. Around 24 were between 42 to 47 years old. A few were 33 to 35 years old. There were 11 who were within the age range of 54 to 71 years old. The youngest parents were 27 to 29 years old.

1.2 *Sex of the respondents.* Table 3 shows the percentage and frequency distribution of the respondents according to sex. Majority of administrators, teachers, and students are female while among the parents only 1 is female and 126 are male. The phenomenon among parents is not surprising because in the Muslim way of life, activities related to the welfare of the children outside the home is delegated to the father.

Table 2. Percentage and Frequency Distribution of the Age of the Respondents

Age range	Administrators		Teachers		Parents		Students	
	No.	%	No.	%	No.	%	No.	%
0							3	1.5
12-14							125	62.2
15-17							71	35.3
18-20							2	1.0
							N=201	100.0
21-23								
24-26								
27-29					1	0.8		
30-32	1	14.3	3	23.0	7	5.5		
33-35			2	15.4	9	7.0		
36-38			1	7.7	26	20.5		
39-41					35	27.5		
42-44	4	57.1	5	38.5	10	7.8		
45-47	2	28.6	1	7.7	14	10.9		
	N=7	100.0						
48-50					7	5.5		
51-53			1	7.7	7	5.5		
			N=13	100.0				
54-56					3	2.4		
57-59								
60-62					5	4.0		
63-65					1	0.8		
66-68								
69-71					2	1.6		
					N=27	100.0		

Table 3. Percentage and Frequency Distribution on the Sex of the Respondents

Sex	Administrators		Teachers		Parents		Students	
	No.	%	No.	%	No.	%	No.	%
Female	6	85.7	10	76.9	1	0.8	137	68.2
Male	1	14.3	3	23.1	126	99.2	61	30.3
No answer							3	1.5
Total	N=7	100.0	N=13	100.0	N=127	100.0	N=201	100%

1.3 *Religion of the respondents.* Majority of the administrators, teachers, parents and students are Muslims. Only 88 out 348 respondents are Christians as shown in Table 4.

1.4 *Educational Attainment of the Respondents.* While it is true that there is a big gap between the student respondents and the rest as far as educational attainment is concerned, still the students have a strong say because they are the ones receiving the instruction imparted by the teachers in the instructional process. Table 5 shows that 4 administrators are master's degree holders, with 4 teachers and 50 parents. There is 1 administrator, 3 teachers, and 2 parents who are doctorate degree holders. Nineteen of the respondents are with Master's units and 64 of the total respondents are college graduates.

The biggest participation came from student respondents, the lower years in the high school, that is 132, and the rest belong to the upper years.

2. *Composition of the present Science Curriculum of MSU-SHS.* It can be seen in Table 6 that the present Science Curriculum of Mindanao State University is composed of the following subject areas: eleven subjects in science; four in Mathematics; four in Pilipino; four in PE, Health, and Music; four in Social Studies; four in Values Education; two in Home Management Technology; two in Research; and one in Citizen Army Training only in the fourth year.

3. *Extent of the Integration of Islamic Doctrines and Teachings.* The reactions of the respondents; the mean of the observations are recorded on the Table 7 and the extent of interpretation is given based on the legend below the table. In the following subjects the extent of integration is described as being to a "moderate extent": Biology 2, Biology 3, Chemistry 1, Chemistry 2, Chemistry 3, and Physics 3. In Physics 2 and Physical Science 1, the degree of integration is to a "very little extent".

In the following subjects, the observations differed. According to the administrators, the extent of integration in Biology 1 is "moderate", but the students believe it is to a "very little extent", the same is true in Earth Science. In Physics 1 the administrators claimed that the extent is to a "very little extent" but the students opined it is to a "moderate extent". The interpretations were based on the

Table 4. Percentage and Frequency Distribution on the Religion of the Respondents

Religion	Administrators		Teachers		Parents		Students	
	No.	%	No.	%	No.	%	No.	%
Islam	5	71.4	11	84.6	83	65.3	142	70.6
Catholic	2	28.6	2	15.4	40	31.5	44	21.9
Non-Islam/ Non-Catholic					13	2.4	15	7.5
No answer					1	0.8		
Total	N=7	100.0	N=13	100.0	N=127	100.0	N=201	100.0

Table 5. Percentage and Frequency Distribution on the Educational Attainment of the Respondents

Educational Attainment	Administrators		Teachers		Parents		Students	
	No.	%	No.	%	No.	%	No.	%
College graduate	1	14.3	1	7.7	62	48.8		
With master's units	1	14.3	5	38.5	13	10.2		
With master's degree	4	57.1	4	30.8	50	39.4		
With doctoral degree	1	14.3	3	23.0	2	1.6		
High school:								
First year							66	32.8
Second year							66	32.8
Third year							34	17.0
Fourth year							32	16.0
No answer							3	1.4
Total	N=7	100.0	N=13	100.0	N=127	100.0	N=201	100.0

means computed from each group of respondents. The computerized t-value results in testing the significance of the differences show the differences, are "not significant".

4. *Comparison of the reactions of teachers and parents as regards the incorporation of Islamic doctrines and teachings in the science curriculum.* The respondents are the teachers and parents because they are directly involved in the education of the children. They are the ones who are in the best position to judge whether the child's behavior shows manifestation of having received instruction along Islamic values and teachings as can be seen in Tables 8 and 9. The parents and the teachers made a unanimous decision that the extent of benefits that could

Table 6. Mindanao State University Science School Curriculum

<i>Subjects</i>	<i>Course Description</i>	<i>Hours</i>
<b>FIRST YEAR</b>		
Science 1	Physical Science	5
Mathematics 1	Algebra	5
English 1	Communication Arts (English w/Phil. Lit.)	5
Filipino 1	Sining ng Komunikasyon 1	3
Social Studies 1	Philippine History & Government	3
HMT 1	Cullinary Arts	3
PEHM 1	Gymnastics & Individual Sports, Personal Hygiene & Intro to Music	3
Values Educ. 1	Edukasyon sa Pagpapahalaga 1	3
Earth Science 1	Earth & the Universe	3
		33 hrs.
<b>SECOND YEAR</b>		
Biology 1	General Ecology	3
Chemistry 1	General Chemistry 1	3
Physics 1	Introductory Physics	3
Mathematics 2	Geometry	5
English 2	Communication Arts 2 (English w/Afro-Asian Lit.)	5
Filipino 2	Sining ng Komunikasyon 2	3
Social Studies 2	History of Asian Nations	3
HMT 2	Handicraft	3
PEHM 2	Softball/Soccer for Boys, Phil. Folk Dance/ Softball for Girls, & Drug Addiction	3
Values Educ. 2	Edukasyon sa Pagpapahalaga 2	3
		34 hrs.
<b>THIRD YEAR</b>		
Biology 2	General Zoology	3
Chemistry 2	General Chemistry 2	3
Physics 2	Mechanics, Heat, & Sound	3
Mathematics 3	Advanced Algebra & Trigonometry	5
English 3	Communication Arts 3 (English w/Ango-American Lit.)	5
Filipino 3	Sining ng Komunikasyon 3	3
Social Studies 3	Economics	3
Research 1	Methods of Research & Introductory Statistics for High School	3
PEHM 3	Basketball & Volleyball, First Aid, & Music w/Arts	3
Values Educ. 3	Edukasyon sa Pagpapahalaga 3	3
		34 hrs.

Table 6 (continued)

<i>Subjects</i>	<i>Course Description</i>	<i>Hours</i>
FOURTH YEAR		
Biology 3	Botany	3
Chemistry 3	Introduction to Organic Chemistry	3
Physics 3	Electricity, Magnetism, Optics, & Modern Physics	3
Mathematics 4	Introductory Calculus	5
English 4	Communication Arts (English w/ World Literature)	5
Filipino 4	Sining ng Komunikasyon 4	3
Social Studies 4	World History	3
Research 2	Research Projects	3
PEHM 4/CAT 1	Lawn Tennis, Population Education & Music/ Citizen Army Training	3
Values Educ. 4	Edukasyon sa Pagpapahalaga 4	3
		34 hrs.

be derived from the incorporation of the Islamic doctrines and teachings in the eleven science subjects are all to a "great extent".

5. *Possibility for the integration of additional Islamic doctrines and values.* Careful analysis of the subjects needing additional integration of Islamic doctrines and values showed that there is a possibility of additional 50 percent integration in the following subjects: Biology 1, Chemistry 1, Earth Science, Physical Science and Physics 1 as disclosed in Tables 10 and 11.

In the remaining six subjects the following were perceived to need less than 50 percent additional integration and these subjects are: Biology 2, Biology 3, Chemistry 2, Chemistry 3, Physics 2, Physics 3, and the two non-science subjects, Social Studies and Values Education.

6. *Comments, suggestions and recommendations given by respondents.* The principal ideas on the comments and suggestions given shown in Table 12 were: congratulatory remarks for work done; integration of more Islamic doctrines and values to make them universal; there must be wide campaign in the Autonomous Region before implementing the findings of the study; there must be an implementation of science and technology based on Islamic doctrines and teachings for both Muslims and non-Muslims.

The recommendations in Table 13 centered on the following: actual implementation by ARMM of the findings of the study, Arabic subjects should be taught, and Islamic values and teachings should be integrated in the Ecology course; teaching of universal doctrine should extend to both Muslim and non-Muslim areas; and teachers should be well-trained to serve as implementors of the integrated program.

Table 7. Observations of Administrators and Students on the Extent of Integration of Islamic Doctrines and Teachings in the Science Curriculum.

Science Subjects	Administrators		Students		Pooled variance Estimate		Interpretation	Separate Variance Estimate		Interpretation
	Mean	Extent of Integration	Mean	Extent of Integration	t-value	DF		t-value	DF	
1. Biology 1	3.0714	ME	2.4028	VLE	1.20	149	NS	0.89	6.31	NS
2. Biology 2	3.3571	ME	2.5729	ME	1.24	101	NS	1.00	5.39	NS
3. Biology 3	3.0000	ME	2.8133	ME	0.36	84	NS	0.26	6.49	NS
4. Chemistry 1	3.0000	ME	2.6775	ME	0.58	143	NS	0.47	6.39	NS
5. Chemistry 2	2.8571	ME	2.5200	ME	0.57	105	NS	0.47	6.55	NS
6. Chemistry 3	2.5357	ME	2.8451	ME	-0.54	76	NS	(0.43)	6.70	NS
7. Earth Science	2.8571	ME	2.4458	VLE	0.68	171	NS	0.60	6.40	NS
8. Physical Science	2.4286	VLE	2.4389	VLE	-0.02	185	NS	(0.01)	6.33	NS
9. Physics 1	2.4286	VLE	2.5319	ME	-0.18	146	NS	(0.15)	6.40	NS
10. Physics 2	2.4490	VLE	2.4926	VLE	-0.08	101	NS	(0.07)	6.63	NS
11. Physics 3	2.6429	ME	2.9188	ME	-0.46	85	NS	(0.38)	6.65	NS

Legend: VGE = Very great extent 4.5-5.0  
 GE = Great extent 3.5-4.49  
 ME = Moderate extent 2.5-3.49  
 VLE = Little extent 1.5-2.49  
 NE = Not at all 0.5-.149



Table 8. Differences in Two Means Obtained from the Responses of the Teachers and Parents

<i>Subject</i>	<i>Mean of Teachers</i>	<i>Mean of Parents</i>	<i>Differences in Means</i>
1. Biology	4.1538	4.0444	0.1094
2. Biology 2	4.3956	4.0536	0.3426
3. Biology 3	4.3846	4.0948	0.2898
4. Chemistry 1	4.3846	4.0754	0.3092
5. Chemistry 2	4.3462	4.0437	0.3025
6. Chemistry 3	4.1538	4.0574	0.0964
7. Earth Science	4.3077	4.2079	0.0998
8. Physical Science	4.1538	4.0574	0.0964
9. Physics 1	4.1538	4.0574	0.0964
10. Physics 2	4.3077	4.2447	0.063
11. Physics 3	4.2308	3.9940	0.2374

Legend:	VGE = Very great extent	4.5-5.0
	GE = Great extent	3.5-4.49
	ME = Moderate extent	2.5-3.49
	VLE = Little extent	1.5-2.49
	NE = Not at all	0.5-1.49

## CONCLUSIONS

1. The study revealed that most of the respondents on the part of the administrators, teachers, and parents were mature and educated. Resultantly, the perceptions on the idea of integration, together with those of the students who are the direct recipients of the educational process is to a "moderate extent".

2. That there is a mutual conformity on the idea about integration of Islamic doctrines and teachings.

3. There is a mutual agreement regarding the benefits that could be derived from integration of Islamic doctrines and teachings.

4. The perceptions of parents and teachers in the study reflect their cooperative endeavor to mold the youth in the observance of virtues in order to become morally upright citizens which our country needs today. This would undoubtedly lead to the reduction of juvenile delinquencies and would contribute to peace and order.

5. The perceptions of the students and administrators demand the inclusion of the Islamic doctrines and teachings in the curricula of all secondary schools regardless of the students' religious affiliations. This stresses the role of formal education in the development of the youth.

Table 9. Extent of Benefits That Could be Derived from the Integration of Islamic Doctrines and Teachings According to Teachers and Parents

Science Subjects	Teachers		Parents		Pooled Variance Estimate		Interpretation	Separate Variance Estimate		Interpretation
	Mean	Extent of Integration	Mean	Extent of Integration	t-value	DF		t-value	DF	
1. Biology 1	4.1538	GE	4.0444	GE	0.33	135	NS	0.37	15.53	NS
2. Biology 2	4.3956	GE	4.053	GE	1.11	108	NS	1.34	17.78	NS
3. Biology 3	4.3846	GE	4.0948	GE	0.98	135	NS	1.33	17.90	NS
4. Chemistry 1	4.3846	GE	4.0754	GE	1.00	137	NS	1.36	17.86	NS
5. Chemistry 2	4.3462	GE	4.0437	GE	0.92	137	NS	1.04	15.49	NS
6. Chemistry 3	4.1538	GE	4.0574	GE	0.27	133	NS	0.29	15.07	NS
7. Earth Science	4.3077	GE	4.2079	GE	0.34	104	NS	0.29	16.37	NS
8. Physical Science	4.1538	GE	4.0574	GE	0.34	133	NS	0.37	15.07	NS
9. Physics 1	4.1538	GE	4.0574	GE	0.34	133	NS	0.29	15.07	NS
10. Physics 2	4.3077	GE	4.2447	GE	0.21	98	NS	0.20	15.31	NS
11. Physics 3	4.2308	GE	3.9934	GE	0.61	87	NS	0.66	16.65	NS

Legend: VGE = Very great extent 4.5-5.0  
 GE = Great extent 3.5-4.49  
 ME = Moderate extent 2.5-3.49  
 VLE = Little extent 1.5-2.49  
 NE = Not at all 0.5-.149

Table 10. Percentage and Frequency Distribution of Subjects Where More Than Fifty Percent (50%) Possibility is Evident for the Integration of Additional Islamic Doctrines and Values N=348

Additional Islamic Doctrines and Values	Biology I			Chemistry I			Earth Science I			Physical Science I			Physics I		
	No.	%	Rank	No.	%	Rank	No.	%	Rank	No.	%	Rank	No.	%	Rank
1. Allah is monotheistic: He is unique; He is everywhere	208	59.77	9	196	56.32	14	210	60.34	16	201	57.76	13	200	57.47	6
2. All nature has been subservient	206	59.2	10	203	58.33	5	208	59.77	17	205	59.91	12	203	53.33	5
3. Almsgiving or charity	209	60.06	8	198	56.9	10	222	63.79	5	211	60.63	10	203	53.33	5
4. Balanced Life	186	53.45	14	198	56.9	10	220	63.32	7	210	60.34	11	211	60.63	1
5. Cheerfulness	184	52.87	15	197	56.61	11	221	63.51	6	217	62.36	6	190	54.6	4
6. Contemplation and deliveration	186	53.45	14	205	59.91	4	223	64.08	4	210	60.34	11	193	55.46	11
7. Courtesy	186	53.45	14	199	57.83	9	226	64.37	3	218	62.64	5	195	56.03	9
8. Friendliness	186	53.45	14	205	59.91	4	221	63.51	6	219	62.93	4	194	55.75	10
9. Frugality	209	60.06	8	208	59.77	2	219	61.49	8	217	62.36	6	197	56.61	7
10. Generosity	208	59.77	9	207	59.48	3	215	61.78	11	213	61.21	8	193	55.46	11
11. Gentleness	219	62.93	2	202	58.05	6	215	61.78	11	219	62.93	4	196	56.32	8
12. Goodness	211	60.63	6	198	56.9	10	220	63.2	7	212	60.94	9	190	54.6	14
13. Gratefulness	211	60.63	6	186	53.45	17	228	65.52	2	224	64.37	2	210	57.76	2
14. Hospitality	190	54.6	13	194	55.75	14	208	59.77	17	225	64.66	1	207	59.48	4
15. Humility	200	57.47	12	199	57.83	9	210	61.49	13	212	60.92	9	209	60.06	3
16. Justice	201	57.76	11	195	56.03	13	229	65.81	1	217	62.36	6	209	60.06	3

Table 10 (continued)

Additional Islamic Doctrines and Values	Biology 1			Chemistry 1			Earth Science 1			Physical Science 1			Physics 1		
	No.	%	Rank	No.	%	Rank	No.	%	Rank	No.	%	Rank	No.	%	Rank
17. Kindness	252	72.41	1	201	57.76	7	198	56.03	18	217	62.36	6	195	56.03	9
18. Mercifulness	208	57.76	9	199	57.83	9	214	61.49	13	219	62.93	4	197	56.61	7
19. Moderation	210	60.34	7	205	57.83	4	216	62.07	10	212	60.92	9	196	56.32	8
20. Obedience	218	62.64	3	190	54.6	16	211	60.63	15	220	63.22	3	207	59.48	4
21. Piety	213	61.21	4	197	56.61	11	214	61.49	12	215	61.78	7	191	54.89	13
22. Purity	212	60.92	5	192	55.17	15	217	62.36	9	211	60.63	10	192	55.17	12
23. Perseverance	184	52.87	15	201	57.76	7	216	62.07	10	186	53.49	16	186	53.49	17
24. Reconciliation	186	53.45	14	200	57.47	8	213	61.21	14	188	54.02	15	188	54.02	16
25. Sincerity	186	53.45	14	218	62.64	1	217	62.36	9	181	52.01	18	181	52.01	19
26. Simplicity	186	53.45	14	202	58.05	6	219	62.93	8	189	54.31	14	189	54.31	15
27. Truthfulness	186	53.45	14	208	59.77	2	216	62.07	10	183	52.59	17	183	52.59	18

Table 11. Percentage and Frequency Distribution of Subjects With Less Than Fifty Percent (50%) Possibility of Integration of Additional Islamic Doctrines and Values N=348

	Biology 2		Biology 3		Chemistry		Chemistry 3		Physics 2		Physics 3		Values Education		Social Studies		No Answers	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	1. Allah is monotheistic: He is unique; He is everywhere	140	40.22	139	39.94	141	40.52	140	40.23	140	40.22	40	40.22	28	7.47			36
2. All nature has been subservient	140	40.22	139	39.94	140	40.23	140	40.23	140	40.22	139	39.94	31	8.05			48	13.79
3. Almsgiving or charity	139	39.94	139	39.94	139	39.94	140	40.23	139	39.94	139	39.37	33	8.91			40	11.50
4. Balanced Life	140	40.22	138	39.66	139	39.94	139	39.94	139	39.94	139	39.37	32	9.48			29	8.33
5. Cheerfulness	138	39.94	137	39.37	138	39.66	137	39.32	149	42.82	37	39.37	33	9.20	1	0.29	29	8.33
6. Contemplation and deliberation	137	39.37	136	39.08	137	39.37	138	39.66	146	41.95	137	39.37	29	8.33	4	1.50	29	8.33
7. Courtesy	137	39.37	137	39.37	136	39.08	137	39.37	147	42.24	136	39.08	31	8.91	2	0.57	29	8.33
8. Friendliness	137	39.37	136	39.08	136	39.08	137	39.37	147	42.24	136	39.08	30	8.62	3	0.86	29	8.33
9. Frugality	136	39.08	137	39.37	136	39.08	136	39.38	147	42.24	139	39.94	30	8.62	3	0.86	29	8.33
10. Generosity	137	39.37	139	39.37	138	39.66	138	39.66	147	42.24	136	39.08	30	8.62	3	0.86	46	13.22
11. Gentleness	137	39.37	138	39.66	138	39.66	137	39.37	146	41.95	137	39.37	30	8.62	3	0.86	46	13.22
12. Goodness	136	39.37	136	39.08	136	39.08	139	93.94	146	41.95	137	39.37	30	8.62	3	0.86	45	12.93
13. Gratefulness	136	39.08	136	39.08	136	39.08	137	39.37	147	42.24	138	39.66	33	9.48			49	14.08
14. Hospitality	136	39.08	137	39.37	137	39.37	139	39.94	147	42.24	137	39.37	29	8.33	4	1.50	20	5.78
15. Humility	136	39.08	137	39.37	138	39.66	138	39.66	148	42.53	136	39.08	33	9.48	1	0.29	48	13.79
16. Justice	137	39.37	137	39.37	137	39.37	136	39.08	147	42.54	137	39.37	33	9.48			38	10.92

Table 11 (continued)

	Biology 2		Biology 3		Chemistry		Chemistry 3		Physics 2		Physics 3		Values Education		Social Studies		No Answers	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
17. Kindness	137	39.37	138	39.66	138	39.66	140	40.23	148	42.53	138	39.66	33	9.48			49	14.80
18. Mercifulness	139	39.94	138	39.66	140	40.23	140	40.23	148	42.53	137	39.37	33	9.48			45	12.93
19. Moderation	139	39.94	137	39.37	137	39.37	139	39.94	148	42.53	137	39.37	33	9.48			45	12.93
20. Obedience	138	39.66	138	39.66	138	39.66	139	39.94	147	42.24	137	39.37	32	9.20	1	0.29	46	13.22
21. Piety	138	39.66	137	39.37	138	39.66	139	39.94	148	42.53	137	39.37	29	8.33	4	1.50	48	13.79
22. Purity	138	39.66	139	39.94	139	39.94	104	40.23	147	42.24	137	39.37	29	8.33	4	1.50	29	8.33
23. Perseverance	139	39.94	137	39.37	139	39.94	141	40.50	147	42.24	139	39.94	29	8.33	4	1.50	29	8.33
24. Reconciliation	139	39.94	138	39.66	138	39.66	139	39.94	148	42.53	139	39.94	29	8.33	4	1.50	29	8.33
25. Sincerity	139	39.94	137	39.37	137	39.37	139	39.94	147	42.24	137	39.37	29	8.33	4	1.50	49	14.80
26. Simplicity	138	39.66	137	39.37	138	39.66	138	39.66	147	42.24	138	39.66	29	8.33	4	1.50	48	13.79
27. Truthfulness	139	39.94	138	39.66	138	39.66	137	39.37	147	42.24	139	39.94	29	8.33	4	1.50		

Table 12. Percentages and Frequency Distribution of the Comments of the Respondents on the Study

Comments	R e s p o n d e n t s								
	Administrators		Teachers		Parents		Students		
	No.	%	No.	%	No.	%	No.	%	
1. Acceptance of universal doctrines by non-Muslims in the Muslim Areas where non-Muslims are minorities	4	57.14							
2. This is a good study for the Muslims	3	42.86							
Total	7	100.00							
3. This work on Islamic teachings is timely.			4	28.57					
4. The study should involve Values Education only			1	7.14					
5. A good study.			4	28.57					
6. Congratulations!			5	35.72					
Total			14	100.00					
7. The study will enrich the lives of the students					130	38.92			
8. The study will benefit the Muslim students. Good work! Congratulations!					62	18.56			
9. Complex simple questionnaires only					3	9.28			
10. Your study is good for Muslim's only! What about non-Muslim students?					30	9.28			
11. Some Islamic doctrines were accepted even by Christians.					71	21.26			
12. The study is possible but not to a pluralistic society like MSU					15	4.49			
13. The study is viable for Muslim schools.					23	6.89			
Total					334	100.00			
14. The Muslim students will be the only ones benefitted by this study.							44	10.73	
15. The study is timely and it is for the betterment of science instruction and unity of all.							16	3.90	
16. Time consuming questionnaires.							18	4.39	
17. Islam was so emphasized.							21	5.12	
18. There must be an application of universal values and doctrines.							87	21.22	
19. The study is unfair to us who are non-Muslims.							19	4.63	
20. The perseverance and dedication of the teachers are vital.									
21. Congratulations for doing this study.							62	15.12	
22. The study is one way of preserving the cultural norms among the Muslims.							59	14.39	
23. No comment							57	13.90	
Total							383	100.00	

Table 13. Percentages and Frequency Distribution on the Suggestions and Recommendations Given to Enrich the Science Curriculum

Suggestions and recommendations	Respondents							
	Administrators		Teachers		Parents		Students	
	No.	%	No.	%	No.	%	No.	%
1. Further researches should be conducted on Islamic Doctrines and Teachings which even Non-Muslims could adopt.	1	16.67						
2. Submit the findings of this study to ARMM officials for implementation.	2	33.33						
3. The commitment of the teachers is greatly needed before the implementation of the findings in the study.	3	50.00						
<b>Total</b>	<b>6</b>	<b>100.00</b>						
4. There should be researches on ways and implementing projects			1	8.33				
5. Islamic teachings and doctrines should be integrated in Ecology			1	8.33				
6. Arabic subject should be included in the Science High School curriculum.			1	8.33				
7. This study should be implemented not only in MSU-SHS but also in the autonomous regions in Muslim Mindanao.			9	75.00				
<b>Total</b>			<b>12</b>	<b>100.00</b>				
8. Autonomous officials must implement this study in all Muslim areas.					47	13.50		
9. Application of universal doctrines.					33	10.92		
10. Modernization of technological advancement.					51	14.66		
11. Implementation of science and technology subjects based on this study.					50	14.36		
12. Science teachers must be trained for the integration program					30	8.62		
13. Muslim officials must work for the actualization.					60	17.24		
14. The researchers must continue this study for implementation.					56	16.09		
15. Only trained teachers must be the implementors.					16	4.60		
<b>Total</b>					<b>348</b>	<b>100.00</b>		
16. Further study must be done before implementation.							18	5.61
17. Add more science subjects especially in the first year.							41	12.77
18. Make science instruction more interesting and realistic.							48	14.95
19. The researcher must continue working for actualization of this study.							43	13.40



Table 13 (continued)

Suggestions and recommendations	R e s p o n d e n t s							
	Administrators		Teachers		Parents		Students	
	No.	%	No.	%	No.	%	No.	%
20. Introduce computerization for technological advancement.							31	9.66
21. Go on with the implementation of findings of this study so that we (students) will know how Islam is related to science.							30	9.34
22. Islamic doctrines should be integrated in all subjects in the high school.							32	9.97
23. Workbooks, modules, or reading materials must be available before the implementation for our reference.							17	5.30
24. Provide advanced training to our teachers.							61	19.00
Total							321	100.00

## RECOMMENDATIONS

As an offshot of the findings of this study, the following recommendation are formulated.

1. A new instrument must be constructed using the perceptions of the respondents in the present study to make the findings reliable and valid.

2. Further studies should be made on the integration of Islamic doctrines and teachings at the secondary level regardless of the religious affiliations of the students, for the development of scientific and morally upright individuals.

3. The preparation of workbooks, modules, and other instructional materials should be developed. The author started the module unit entitled "Ideas in Teaching Through Integration" that could be defined later (Attached exemplar module).

4. The effectivity of instructional materials could be determined in an experiment using two sets of high school groups. One group will be subjected to the curriculum which has the material for the integration of Islamic doctrines and teachings, while the other will be the control group to be subjected to the same curriculum but without the integration of Islamic doctrines and teachings in the science curriculum.

It is hoped that the above recommendations will merit the attention and considered by the people involved for the greater benefit of the students and the country as a whole. This is a step in answer to the foresight of "Philippines 2000" towards quality education.

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## **ISLAMIC DOCTRINES ON EARTH AND ALLIED SCIENCES IDEAS IN TEACHING THROUGH INTEGRATION\***

There is wisdom behind the creation of everything in this world. Look around and reflect upon everything in this world. Look around and reflect upon everything you see, what will happen in case you miss something in this life, whether this something belongs to you or to others. If everything were created for a purpose and each thing were a part of a system, if the tissue or a cell were created for a purpose, then the existence of humans in this universe is for a great purpose.

The writer made careful observation in order to give the meanings of the Islamic verses using accepted scientific facts. The scientific explanation of the verses were in line with the Quranic texts because human knowledge and scientific theories can be subjected to change unlike Islamic doctrines which are inclusive and fixed words.

Moreover, Allah (S.W.T. referring to Almighty God) made and put man and woman on a dignified position among all creatures. Such being the case, Islam which is a way of life meant for the whole world to practice and not intended solely for the Muslims.

Resultantly, one way of practicing Islam, which in turn is serving Allah (S.W.T.) is to gain knowledge to seek for truth. It is the objective of this module to link Islamic Doctrines on Earth and Allied Sciences (IDEAS) with Teaching Through Integration. The direct recipients of the contents of the module are Muslim learners will be exposed to the Islamic Doctrines projecting Earth and Allied sciences concepts, so that beneficial results can be expected. Aims and objectives are reconciled to a great extent to the teachings of Quranic Verses and to the scientific literatures fourteen centuries ago. The researchers and the concepts found on the verses chosen were made through an interdisciplinary approach. An approach that could serve as a network of desirable values that would develop a balanced man imbued with capacity to receive all the benefits of man.

\*Exemplar module presented by Dr. Emerita "Hadja Amara" Panlaque-Moti, of the Faculty of Science Training Center, during the International Seminar-Workshop of Islamic Thought of Disciplines at the Mindanao State University, Academic Complex, Marawi City, Dec. 15-17, 1995.

Allah (S.W.T.) Sayeth:

“No want of proportion without thou see in the creation of Allah most Gracious and most merciful ...”

Sura Mulk LXVII (Verse 3)

This means that there is only one general absolute law for creation. Allah (S.W.T.) is taking care of His creation. We live under His mercy and therefore in return we should be obedient to Him.

Allah (S.W.T.) says:

“It is he who hath produced you from a single person.”

Sura An'am VI (Verse 98)

“Nor is hidden from thy Lord (so much as) the weight of an atom on earth or in heaven. And not the least and not the greatest of these things but are recorded in a clear record.”

Sura Yunus X (Verse 61)

Every material thing in this widely extended universe from the sub-atomic particles up to the largest galaxies is moving according to a divine definite geometry and an exact calculations besides being in a precise order. It is like an atom, which is the smallest thing, very small that ten billions atoms will not even exceed a pin head. The atom is likened to a small universe attaining all order in the universe. Most of the atom's material is concentrated in its nucleus at the center and around it is a discreet cloud of electrons. The nucleus of the atom comprises almost all of the atomic mass. It is the sun that contains almost all of the solar systems mass! So the nucleus of the atoms that of the sun. Let it be noted that the electrons revolve around the nucleus as the planets revolve around the sun. There is resemblance in the distance of electrons which move from the nucleus and those between the planets and the diameter of the solar system. The forces of attraction between the positive protons inside the nucleus and the negative electrons have laws that create their own orbits, the same thing takes place in the solar system. The energy released by the destruction of atoms in nuclear energy devices is present in the sun to a magnitude of the difference between an atom and a star like sun. This explains the phenomenon regarding the sun's heat and light. The abovementioned behavior is a proof that the Almighty creator Praise be to Allah (S.W.T.) who created this enormous universe in infinite.

This orderly universe which is amazing in its volume and splendid in structure and in its balanced motion is apt to collapse if the minutest disorder confronts it at any moment. At this point man in his aim to control the wealth of the universe destroying the balance of homostasis generally by means of over population, by using and releasing active elements destroying the ozone layer and causing the El Niño will eventually cause the collapse of the earth.

Take note of the following:

1. If the earth is twice its present distance from the sun, then the quantity of heat that the earth will receive will be reduced to one fourth, then winter will be double and all the biota would be freezing to death!

2. If the sun is half its present distance from the earth, then the temperature will be four times as high as the earth will not be fit for life and revolution of the earth will be doubled, no seasons, no vegetations and the result is no life.

3. The earth's atmosphere protects its surface from stockpiles of millions of meteorites, which come from outer space and dissipate the cosmic rays which could have been fatal for any kind of living thing.

4. The atmosphere is a factor in keeping the temperature of the earth's surface as it is. It is the medium that develops the humidity evaporated from oceans to clouds then to rain. The cycle of water from surface to atmosphere is what saves the earth water from stagnance and decadence.

5. The composition of the atmosphere has its significant role in the development of earth.

6. If oxygen is 50 percent or more instead of 21 percent, then all combustible materials could have caught fire at the first strike of lightning. If the percentage of oxygen is 10 percent for example, it could not have developed the present status condition for human existence.

7. If chlorine does not form salt with sodium, no life could have been developed. Salt is antidecadence.

8. The lower temperature of the poles retains quantity of water that would have drowned most of the cities and cultivations. On earth would it be if the temperature of the poles is raised just a few degrees.

9. If the earth was like the planet Mercury, half day light with high temperature and half night with low temperature all the time, then life would be impossible because biological processes cannot adapt to extreme temperatures.

## **AN ASSESSMENT OF THE POSSIBILITIES AND LIMITATIONS OF THE EAST ASEAN GROWTH AREA**

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### **ABSTRACT**

This paper attempts to analyze the possibilities for economic integration among continuous areas that comprise the East ASEAN Growth Area (EAGA). The weakness of economic complementarities is analyzed, the intra-ASEAN trade pattern is discussed, and possibilities for exploiting EAGA's potential are indicated. Even if EAGA cannot be justified on efficiency reasons, it may have served an incidental objective of putting pressure on central governments to allocate more development resources to its much neglected depressed regions. The choice of infrastructure projects for Mindanao and the formulation of the Philippine political commitment to EAGA are suggested to be supportive of exploiting the competitive advantage of Filipino firms which aim to take advantage of EAGA's business opportunities.

### **I. INTRODUCTION**

There is a scarcity of literature assessing the status, problems, and prospects of the East ASEAN Growth Area (EAGA). Furthermore, much less research has been undertaken on the relationship between the choice of infrastructure projects in Mindanao (i.e., projects intended for South Cotabato – Sarangani – General Santos area) and infrastructure facilities supportive of Mindanao's participation in EAGA.

While other growth triangles (i.e., Southern China Growth Triangle and Johor-Singapore-Riau Growth Triangle) have been well analyzed, no in-depth assessment of EAGA's possibilities (particularly for Mindanao) exists. The only known study dealing with EAGA is the on-going ADB study whose results are still to be officially and publicly released. It is therefore instructive to set the pace of stimulating research on the limitations and possibilities of EAGA in the hope of formulating and designing appropriate policy initiatives and clarifying the issues affecting the progress of EAGA's development.

The discussion of the paper is organized as follows: Section II analyzes the rationale for EAGA. It likewise discusses the key success factors characteristic of growth triangles in Asia. Section III explains the extent and magnitude of intra-ASEAN trade. Subregional realities are discussed in Section IV, followed by a discussion on the choice of infrastructure projects in Mindanao in Section V. EAGA's business opportunities are explained in Section VI, and its perceived role to the region is stressed in Section VII. Finally, the paper concludes with a brief discussion of the need for policy coordination for Mindanao to take advantage of EAGA's possibilities.

## **II. RATIONALE FOR EAGA-BIMP**

The East ASEAN Growth Area (EAGA) is a subregional economic zone comprising segments of the territories of four ASEAN countries, namely, Brunei, Indonesia, Malaysia, and the Philippines (BIMP). The EAGA "growth triangle" or "growth polygon" links Brunei with Sabah, Sarawak, Labuan, West Kalimantan, East Kalimantan, North Sulawesi, Mindanao, and Palawan. EAGA has a population of 30 million people and was formally launched in March 26, 1994 in Davao City, Philippines.

Trading blocs (e.g., AFTA, NAFTA, APEC, and SAARC) have been set up to promote trade and investment among member countries. However, trading blocs are more problematic than growth triangles because trading blocs require: (a) large volumes of internal trade, (b) similar laws and regulations to govern trade and investment transactions among member countries, (c) per capita income levels of member countries which are much closer to each other, (d) geographical proximity, and (e) political commitment and policy coordination among member countries. While the last two factors are also applicable to growth triangles, the latter is superior to trading blocs because: (1) it requires changes in institutional and administrative arrangements in only parts of the member countries, (2) can be established in a short-time at a lower cost, and (3) a country can set up several growth triangles simultaneously (Tang and Thant 1994).

The most important factors behind the success of Asian growth triangles (e.g., Southern China Growth Triangle and Johor-Singapore-Riau Growth Triangle) are: economic complementarity, geographical proximity, cultural affinity, infrastructure development, government support and policy coordination (Lee 1992; Tang and Thant 1994; Chen and Ho 1994; and Naidu 1994).

### **(i) Economic Complementarity**

Economic complementarity refers to relative factor cost among areas in the regional subgrouping. For instance, the success of the Southern China Growth Triangle can be ascribed to rising costs of unskilled labor and land rent faced by Hong Kong and Taiwan manufacturers. In contrast, Guangdong and Fujian provinces in Southern China have abundant labor, land, and natural resources. In addi-



If anything, Mindanao's good quality human resource can complement Labuan's work force deficiency, but this requires an agreement among EAGA members on cross-border travel.<sup>1</sup>

### **(ii) Geographical Proximity**

The geographical proximity of EAGA is probably an important factor to enhance intra-regional trade. For instance, Brunei, Sabah, and Kalimantan are located in the same Borneo Island. Sabah in turn could be reached in a few hours via motorboat from Tawi-Tawi and Sulu. Sulawesi and Mindanao are adjacent to each other and have been undertaking trade with each other historically. Davao and Manado have likewise conducted trading activities and transportation links long before EAGA was launched. This proximity could facilitate trade and investment because information and transportation costs are minimized. Similarity between language and culture between Brunei, Sarawak, Sabah, Labuan, Kalimantan, Sulawesi, and parts of Mindanao are likewise facilitating closer business and trade relations.

### **(iii) Infrastructure Development**

This is probably the next important key success factor, after economic complementarity. At present EAGA's infrastructure facilities are inadequate. Air and sea links between different points in EAGA are still inadequate and are basically oriented towards the national capital area. Another stumbling block is the inadequate and erratic power supply as well as high power prices faced by the Malaysian and Philippine segments of the growth triangle. However, if agreement on free travel is made, the densely-populated areas (e.g., Mindanao, Kalimantan, Sulawesi) would be enough to complement sparsely-populated areas (e.g., Brunei, Sarawak, Sabah, and Labuan), and human resources would be less of hindrance to EAGA's development. There is evidently a growing need for cross-border investments in energy, telecommunication facilities, ports, airports, roads, storage and warehousing facilities, grains and livestock handling facilities, and tourism estates.

### **(iv) Government Support**

The political commitment of EAGA governments towards a successful development of the growth triangle is desirable. Suggestions have been made for a high-level government commitment to adopt confidence-building cooperation such as the abolition of travel tax, the simplification in customs and immigration proce-

<sup>1</sup>A motorboat and its cargo carrying 117 passengers from Sabah, Malaysia was seized by the Philippine Navy in Pearl Bank, Tawi-Tawi (Philippine Daily Inquirer, March 16, 1996). Easy travel within EAGA calls for legalization of informal cross-border barter trade or requiring only passes and not formal documents such as passports.

dures, the organization of joint investment promotion missions, and the interconnection of cross-border energy grids. When comparative advantages are strongly complementary market forces and private sector initiatives can accelerate the development of the growth triangle as experienced in the Southern China Growth Triangle (Thang and Thant 1994). In JSR triangle, the pace of development quickened after the meeting between President Suharto and Prime Minister Lee Kuan Yew in October 1989 and Prime Minister Mahathir Mohammad endorsed the JSR concept in 1989 (Kumar 1994). In EAGA's case, what is needed is a high-level meeting between the Sultan Brunei and the President of the Philippines to produce bilateral agreement on labor migration to be followed by a high-level meeting between the President of Indonesia and Prime Minister of Malaysia for a bilateral agreement on the marginal gas utilization in West Natuna, Kalimantan. To encourage investor confidence, the government must promote and undertake joint ventures especially in establishing telecommunication and tourism facilities within the triangle. Once private sector willingness to invest is established, the government's role must be that of ensuring a level playing field such as provision of basic services and enforcement of property rights. Beyond the confidence-building measures, political commitment and policy coordination on implementing complicated policies such as on exchange rate, tariff and non-tariff barriers, investment incentives, and employment must be addressed subsequently.

### III. INTRA-ASEAN TRADE

As mentioned in the previous section, one attribute in which the establishment of growth triangle is superior to the formation of trading blocs is that it does not require large volumes of internal trade. This attribute is not exactly valid to the trading patterns observed among the parties in the southern China Growth Triangle and Johor – Singapore – Riau Growth Triangle. The growth rate of Hong Kong's import from China in 1991 was 24.2 percent which was about 37.7 percent of Hong Kong's total imports. On the other hand the growth rate of Hong Kong's exports to China in 1991 was 31.2 percent which was about 27.1 percent of Hong Kong's total exports. And these figures follow a rising trend. And if imports for re-export are included the share went up to approximately 60 percent. The same trend was observed for indirect trade between Taiwan and China, although the absolute volumes were at a lower magnitude compared to that of China – Hong Kong trade (Chen and Ho 1994). As of 1990, Singapore-Malaysia trade was about 49.2 percent of intra-ASEAN trade and Singapore-Indonesia trade was about 12.0 percent (Hill 1994). In all studies that document the pattern of ASEAN trade, their findings point to one conclusion: the proportion of ASEAN trade with the rest of the world is more significant compared to intra-ASEAN trade (Wong 1985; The 1993; and Hill 1994). Intra-ASEAN trade ranges from 15 percent to 18 percent of total ASEAN trade, and over 80 percent of intra-ASEAN trade deals with Singapore (see Table 2 and Hill 1994).

#### IV. SUBREGIONAL REALITIE

EAGA members face the realities that they have different political and regulatory framework, and their integration could not rely on exploiting differences in factor endowments to promote trade, investment, and growth because such opportunities are not economically evident. The labor-surplus and mineral-rich areas of Kalimantan, Sulawesi, Mindanao, and Palawan are weekly complemented by the labor-scarce but not necessarily capital-rich areas of Sabah, Sarawak, and Labuan. Brunei is capital-rich but its investments have been historically flowing to U.S., Europe, Singapore, and West Malaysia. To divert these investment flows to EAGA, Brunei needs a restructuring of its economy to shift its focus from one that is mainly dependent on oil exports to one that is focused on manufactured exports, and take advantage of abundant factors available in EAGA. EAGA opportunities must likewise offer a rate of return on investment at least equal to what Brunei's investments are currently earning. Brunei is reported to be initially interested as the center for transshipment facility and for promotion and exhibition of EAGA products.<sup>2</sup> One possibility for cooperation and complementarity is how soon Labuan succeeds in its goal of becoming the regional financial center. Assuming the right infrastructure facilities are in place, Labuan's success creates a need for competent and medium-cost workforce which Mindanao (and probably Palawan) could provide. But the most realistic strategy for EAGA is to become an export-oriented production center serving the markets of industrialized countries. But such strategy implies that EAGA will have to aggressively and competitively bid to attract external foreign investors are currently investing in existing and successful growth triangles in other Asian regions.

#### V. MISPLACED PRIORITIES

An international donor agency has distorted priorities in development projects in Southern Mindanao. The Philippine government has been preempted to provide financial support to the new General Santos City airport whose priority should have been last in that region's hierarchy of needs: fish, port, water supply, streetlights, drainage system, telephone system, and health infrastructures. While the airport construction project was initially funded by the U.S. Agency for International Development (USAID) using American firms for construction and supervision, the Philippine government is committed to spend at least P150 million for airport equipment, navigation aids, and improvement of existing embarkment on the west side of the airport runway. A recurrent expenditure for the hiring of manpower to operate, supervise, and maintain the airport would likewise be incurred. And t

<sup>2</sup>See "Small, Medium-Sized Companies to Gain from East ASEAN Triangle," *Philippine Daily Inquirer*, June 27, 1995.

his project may yet become the greatest white elephant in Mindanao. While DOTC has mandated Davao's airport to be an international airport after Manila and Cebu, a foreign-assisted development project proceeded to impose its wish and build another airport from an area which could be reached from Davao by land transportation within 2 hours if priority was given to the rehabilitation of the Davao-General Santos highway. All objectively-measured economic and financial feasibility indicators pointed to the superiority of rebuilding the Davao-General Santos road, expansion of the Makar Port, establishment of the fishport construction of water supply system, improvement of streetlights and drainage system, establishment of telephone and telecommunication facilities, building of grain storage and warehousing facilities, and provision of social, health, and community services. Table 5 shows that USAID-funded road projects are on average more costly than ADB-funded projects. An analysis of the economic profitability of three alternative infrastructure projects in South Cotabato-Sarangani-General Santos City area or what is called SOCSARGEN (see Table 6) shows that the improvement of the Makar Wharf is more economically desirable than building a new international airport. But what actually happened in SOCSARGEN was that a new airport was built and improvement of the Makar Wharf was given less priority. A classic case of economic nonsense.

The internal rate of return on the Makar Wharf project was estimated at 178 percent by a feasibility study undertaken by Louis Berger International, Inc. in 1991 while the internal rate of return for constructing a new international airport at Tambler was only 38.32 percent as estimated by the feasibility study undertaken by Wilbur Smith Associates in 1991. Who benefits from the construction of an international airport? A multinational agribusiness firm that owns a private port or a multitude of citizens that patronize the inter-island shipping industry whose activities could to be accommodated by the limited capacity and poor navigation equipment currently faced by Makar Wharf. But defying all economic logic, an international airport was preferred with the blessing of the foreign funding source. But the question to be asked is why create two airports in Southern Mindanao adjacent to each other? Why build two duplicative infrastructures in the midst of other priority and worthy development projects vying for scarce investment resources? The convoluted logic advanced to support the construction of new General Santos City airport is "to accommodate bigger crafts with higher payload capacity such as Boeing 747 jets and facilitate the dispatch of commodities with minimum spoilage and deterioration" (Manila Bulletin, December 10, 1995). The possibilities are unlimited but one scenario looks like this: DHL and Federal Express planes take off from Subic for a sidetrip to General Santos City and pick-up a cargo of agro-fresh perishable exports produced by Dole Philippines, Inc. and deliver it to the tiger markets of Japan, Taiwan, Hong Kong, and Korea. But why are our much richer neighbors not following this strategy? Because for Indonesia to build international airports in Manado, Balikpapan, and Bitung and for Malaysia in Labuan, Sindakan, and Kota Kinabalu would not only violate economic logic but would pit one city against

Table 5. Philippines Comparative Cost of Road Improvement Project, 1993

	<i>Cost / Km</i>
1. ADB Road Projects	P 4,082,292
2. SOCSARGEN Road Projects <sup>a</sup>	6,553,204
3. Other USAID/RIF Road Projects <sup>b</sup>	8,988,588

Source: E. Patalinghug, "Mid-Term Evaluation of the Mindanao Development Project," unpublished manuscript, July 2, 1993.

<sup>a</sup>Refers to road projects for the South Cotabato-Sarangani-General Santos City area built by U.S. contractors under USAID funding.

<sup>b</sup>Refers to USAID's Rural Infrastructure Projects (RIF) in other areas (i.e., Iloilo, Batangas, Quirino, Palawan, Mindoro Oriental, Bicol Region, and Agusan).

Table 6. Comparative Internal Rate of Return of Infrastructure Projects in South Cotabato-Sarangani-General Santos City Area, 1993

<i>PROJECT</i>	<i>IRR</i>
1. Road	14.46%
2. Wharf	18.78%
3. Airport	13.42%

Source: E. Patalinghug, "Mid-Term Evaluation of the Mindanao Development Project," unpublished manuscript, July 2, 1993.

another<sup>3</sup> and create excess capacity in airport infrastructure when acute scarcity in all other basic infrastructures exists in the region. What's next in this regional madness for "airport complex"? Cagayan de Oro City and Zamboanga City would demand equal treatment and request for funding support to build their own version of Mindanao's new set of international airports. After all a sense of fairness is contagious. But this "madness" has to cease, and economic sense in Mindanao's development strategy has to be restored by defying pressure to follow the priorities of foreign donors whose multinational business interests are not necessarily

<sup>3</sup>When Subic Bay Metropolitan Authority forged a business pact with General Santos City in March 16, 1996, Davao City requested similar investment promotion agreement with SBMA (see *The Spirit of Subic*, March 25, 1996).

consistent with the interest of Mindanao's fragmented groups of small farmers, workers, enterprises, and fisher folks (McAndrew 1993). But since there is no such thing as a free lunch, the right question to be asked is who pays for the cost of convenience (dispatch from General Santos City of perishable products such as tuna, apricots, and cut flowers to Asian regional markets) instead of through Davao City's port and airport? Answer: the people of Mindanao in particular, and the Filipino taxpayers in general. Convenience for big exporters in South Cotabato is subsidized by the rest of the economy.

## **VI. BUSINESS OPPORTUNITIES**

With a population of 30 million in 1995 and estimated at 44 million in 2010, EAGA is a promising consumer market. One of the non-manufacturing areas most likely to exploit EAGA's business opportunities is retailing. The most likely players to watch are: Dairy Farm (Hong Kong), Hutschison Whampoa (Hong Kong), Matahari Putra Prima (Indonesia), Coles Myer (Australia), Woolworth (Australia), SM (Philippines), DAIEI (Japan), and JUSCO (Japan). In construction, companies from Japan and South Korea will probably have an edge in terms of having modern equipment and ample working capital, but supply of unskilled workers will probably come from Indonesia (Kalmantan and Sulawesi) and supply of skilled workers will have to be sourced from Philippines (Mindanao and Palawan). Japanese, Taiwanese, Hong Kong, and South Korean investors are the most probable players in the banking and tourism-services market, but their capital resources have to be complemented by manpower resources in the growth triangle which are most probably to be supplied by Indonesia and Filipino workers.

Shipping is another business opportunity to exploit. WG & A shipping company can target the EAGA for its regional expansion plans. In general, it can look into the financial viability of the Bitung-General Santos route. Unfortunately, air linkages established earlier within EAGA were under utilized and were beset with low passenger capacity.

In food manufacturing, San Miguel Corporation (Philippines) would face stiff competition from food companies from Australia, New Zealand, and Japan. The challenge for Philippine policy makers is to formulate and design policies so that any high-level discussion on the EAGA regulatory and public policy framework that would be agreed later on by high-level government officials will be supportive of enhancing our firms' ability to compete in EAGA, and will create opportunities for the utilization of our human resources in economic activities that exploit our comparative advantage.

## VII. EAGA'S PERCEIVED ROLE

Despite the evident lack of economic complementarities, businessmen, government officials, and donor agencies continue to raise (false?) expectations for the people in the region. This is evident from advanced press releases of an ongoing study funded both by the Asian Development Bank (ADB) and the Government of Brunei. But this is understandable, development analysts have argued that even if no economic complementarities exist among EAGA countries, its ability to become an export-oriented production center servicing the export-oriented and labor-intensive manufacturing industries of non-EAGA countries (i.e., Hong Kong, Taiwan, Japan, and South Korea) is one rationale for its existence. But even if economic efficiency justification does not exist, proponents of EAGA argue that the long neglect of EAGA by their respective central governments is enough to bring attention to its development plight. Tables 7 and 8 support this argument. Table 7 shows that the share of Kalimantan and Eastern Indonesia in manufacturing value added is insignificant compared the share of Java alone. In the same manner Table 8 shows that Mindanao's share of manufacturing value added is insignificant compared to the share of Luzon (and that of the National Capital Region). EAGA is giving hope to the people in the region as a vehicle to correct regional disparities in the same manner as Guangdong and Fujian provinces succeeded in directing economic activities from the Beijing-Shanghai axis. However, as discussed earlier in this paper, differences in factor endowments in the Southern China Growth Triangle create complementary comparative advantages which are not true to EAGA.

## VIII. CONCLUSIONS

The future prospects of the East ASEAN Growth Area (EAGA) would most probably depend on exploiting complementarities between EAGA and investor countries such as Japan, Hong Kong, Taiwan, and South Korea. The latter's abundant capital and scarce supply of unskilled labor and land would complement EAGA's scarce capital and abundant supply of unskilled labor and land. Another rationale for EAGA's existence is to serve as a vehicle for the less developed regions to get a fair share of attention and resources in the development strategies formulated and executed from the seat of government. To enhance Philippines' participation in EAGA, the choice of infrastructure projects must be supportive of strengthening Mindanao's capability to exploit opportunities offered by EAGA. Thus, the choice of constructing a new international airport in General Santos City instead of expanding its Makar Wharf is not supportive of the Philippines' commitment to EAGA in the area of shipping, fishery, trade, and low-cost-high-volume passenger transportation. This paper argues that the policy initiatives and political commitment of the Philippine government must aim at creating a regulatory and policy framework for EAGA in which Filipino firms can exploit their competitive advantage and benefit from the potential business opportunities in EAGA.

Table 7. Indonesia Regional Distribution of Manufacturing, 1986-1991 (Percent of Total Value Added)

A. Excluding Oil and Gas Processing						
<i>Region</i>	<i>1986</i>	<i>1987</i>	<i>1988</i>	<i>1989</i>	<i>1990</i>	<i>1991</i>
Java	75.7	74.4	73.0	73.1	74.6	74.8
Jakarta/West Java	44.1	43.4	43.4	42.4	42.3	41.3
East Java	20.0	19.1	18.7	19.5	20.7	20.9
Sumatra	15.5	15.8	16.8	17.2	15.5	15.2
Kalimantan	5.8	6.5	6.8	6.4	6.5	6.7
Eastern Indonesia	3.1	3.4	3.4	3.3	3.4	3.3
B. Including Oil and Gas Processing						
<i>Region</i>	<i>1986</i>	<i>1987</i>	<i>1988</i>	<i>1989</i>	<i>1990</i>	<i>1991</i>
Java	61.1	62.4	61.6	64.0	65.5	65.7
Jakarta/West Java	32.7	33.5	33.0	32.8	33.8	33.0
East Java	14.9	14.4	14.3	15.5	16.5	16.7
Sumatra	24.4	21.7	22.0	21.8	19.9	19.3
Kalimantan	12.3	13.2	13.8	11.6	11.9	21.4
Eastern Indonesia	2.3	2.6	2.6	2.7	2.7	2.6

Source: H.H. Aswicahyono, K. Bird and H. Hill, "What Happens to Industrial Structure When Countries Liberalize? Indonesia Since The Mid - 1980s," *Journal of Development Studies*, Vol. 32, February 1996, Table 6, page 355.

Table 8. Philippines Regional Distribution of Manufacturing, 1975-1988 (Percent of Total Value Added)

<i>Region</i>	<i>1975</i>	<i>1980</i>	<i>1985</i>	<i>1988</i>
Luzon	79.78	79.28	79.73	77.15
National Capital Region	52.10	53.19	51.73	46.87
Ilocos Region	0.88	0.97	1.37	2.16
Cagayan Valley	0.49	0.48	0.35	0.39
Central Luzon	8.66	8.29	8.18	8.09
Southern Tagalog	17.27	15.99	17.74	19.23
Bicol Region	0.39	0.36	0.37	0.41
Visayas	12.18	12.28	10.45	9.39
Western Visayas	7.75	7.05	4.75	2.79
Central Visayas	4.06	4.91	5.42	6.17
Eastern Visayas	0.36	0.32	0.28	0.42
Mindanao	8.04	8.44	9.81	13.46
Western Mindanao	0.48	0.47	0.70	0.92
Northern Mindanao	2.49	2.54	3.45	5.13
Southern Mindanao	2.99	3.31	3.30	4.03
Central Mindanao	2.07	2.12	2.37	3.39

Source: M.B. Lamberte, et al., *Decentralization and Prospects for Regional Growth* (Manila: Philippine Institute for Development Studies, 1993), Table 24, page 63.



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## **SCIENCE ACROSS ASIA PACIFIC PROJECT**

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### **INTRODUCTION**

Established under the Southeast Asian Ministers of Education Organization (SEAMEO), the mission and goal of the Regional Centre for Education in Science and Mathematics (RECSAM) is to improve the teaching and learning of science and mathematics in schools among the SEAMEO Member Countries, namely: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam: Home to RECSAM is Penang, Malaysia.

Since its foundation in 1967, RECSAM has been innovative and dedicated to extending access to science and mathematics education not only to SEAMEO Member Countries but to non-members as well. And, in today's age of collaboration, RECSAM has worked closely with British Petroleum (BP), one of the world's largest international oil and petrochemical companies operating in some 70 countries. Such partnership in this Science Across Asia Pacific (SAAP) Project has been successful for the past five years.

### **BACKGROUND AND RATIONALE**

The SAAP Project introduced an innovative approach to learning Science-Technology-Society (STS) issues through encouraging communication among school learners in different Asia Pacific Countries. The exchange of communication coming from participating schools located in various parts of Asia Pacific is quite unique.

The Project was patterned in concept after the Science Across Europe Project, also a collaboration between BP and the Association for Science Education (ASE) of the United Kingdom. The aims and expected benefits agreed by participating ministries for this Project are:

- \* Introduce an Asia Pacific dimension into science education by raising awareness, cross-cultural perspectives, ways of life, and national traditions of students in Asia Pacific Countries;
- \* Raise awareness of the ways in which science and technology interact with science, industry, and the environment.
- \* Provide opportunities for students to develop communication skills, including languages other than their own; and
- \* Provide opportunities for schools in different countries to collaborate.

### **PHASE ONE: DEVELOPMENT, TRIALS, AND FEEDBACK**

#### **Development**

The First STS Development Workshop initiated by RECSAM in collaboration with BP and the British Council from 16-20 December 1991 saw the birth of the SAAP Project. Participants included Education Ministry representatives, science teachers from the six member countries attending STS at RECSAM, and resource persons from Australia, Canada, Singapore, and United Kingdom.

The output resulted in the production of three trial units on STS: Drinking Water, What Do You Eat, and Energy at Home. These units were adapted from Science Across Europe units to make them relevant to the participating countries and the culture of Asia Pacific, and were translated into Thai, Bahasa Malaysia, and Bahasa Indonesia.

#### **Trials**

With RECSAM as the coordinating agency, the trial units were packaged and distributed to 45 schools in eight countries listed in the network. The basic teaching units provide: an introduction to the project and explanation on how it works; teachers and students notes; a registration form to enable schools to join the database, exchange relevant supporting maps and data; and exchange forms to facilitate exchange of class research data between and among schools in different countries.

#### **Feedback**

Responses from the participating schools were encouraging. Teacher respondents of the evaluation particularly welcomed the following points:

- \* Increased student awareness of the interaction between science, technology, and society, especially on environmental issues;
- \* Community-based research by students;
- \* Introduction to innovative investigatory teaching methods, and
- \* Introduction to the perceptions and concerns of students from other countries and cultures in the SEA Region.

In August 1993, the final revisions to the trial units were published and reissued to an expanded network, taking into consideration teachers' suggestions for improvement, as much as possible.

## **PHASE TWO: DEVELOPMENT PLANS AND PROGRESS**

In January 1993, the Second Development Workshop was held, again at RECSAM, comprising the majority of the Phase I Development team members. There were additional teachers and, for the first time, a representative from Viet Nam.

The Phase II work:

- \* Finalized the first three units based on feedback from the 1992 trials;
- \* Reviewed and improved the international exchange process;
- \* Drafted additional teaching units in the following areas, Tropical Forests, Global Warming, Domestic Waste, and Renewable Energy;
- \* Trained a new group of teachers to assist in the development of new materials and to try out the new units in their countries; and
- \* Agreed on an expansion plan, explore the implications for institutionalizing the teaching materials, and exchange process in each participating country.

### **Progress**

The objectives were fully met and an expansion program was planned. Among the provisions were: Viet Nam and Canada would join the network on a trial basis and all seven teaching units would be made available in English, Thai, Bahasa, and Vietnamese.

The expansion efforts by national coordinators resulted in strong growth in Indonesia and Malaysia, followed by the Philippines, Thailand, and Singapore.

## **THIRD DEVELOPMENT WORKSHOP**

Seventeen participants who convened for the 3<sup>rd</sup> development workshop at Bandung, Indonesia on 17-19 January 1994 met the following objectives:

- \* Reviewed success of Phase II expansion;
- \* Reviewed Book Two units;
- \* Shared country plans;
- \* Planned Phase III development; and
- \* Built a collective vision for future collaboration.

A summary of evaluation results shows that: 90% of students like the units; 89% of teachers are satisfied; 98% feel units fulfilled aims; 92% will use them again; there was 60% collaboration with other subjects; most teachers agree that units fit curricula; the language level is suitable; and the concepts and skills are worthy.

The long term vision is to see the birth of Science Across the World involving three interlinked regional networks; some 30 to 50 thousand schools; 10-20 globally relevant units, and some 100 countries.

#### **FOURTH DEVELOPMENT WORKSHOP**

On 18-22 September 1995, BP sponsored the 4<sup>th</sup> development workshop of SAAP at SEAMEO RECSAM which successfully:

- \* Produced new units on Acid Rain, Disappearing Wetlands, Plants in Our Lives and Diseases – Cause, Cure, and Care;
- \* Discussed and decided on making Science Across Asia Pacific more effective; clarified roles and responsibilities of national coordinators and BP;
- \* Designed an effective network among BP Managers in charge of SAAP, National Coordinators, Resource Persons, and Writers;
- \* Planned to link up with Science Across Europe, Science Across America, Science Across Africa (the last two being in their formative stage) and establish a Science Across the World network; and
- \* Trained national coordinators on the management of SAAP and the use of the database and Internet.

Some facts and figures about Science Across the World show that: 300 schools in 22 European countries are currently taking part in the program, more than 500 schools and 100 teachers in 14 Asia Pacific countries are participating, some of the teaching units are being extended to all schools in Indonesia in a Ministry of Education-led initiative, and it is the only cross-country science initiative for African students.

#### **SUGGESTED INCENTIVES FOR PARTICIPATING SCHOOLS**

Each school that registers will be given one periodic table. Schools that have made successful exchange with at least five other schools outside the country will receive a world map. Evidence of exchange must be provided. Moreover, students who have successfully participated in the project including the exchanges will be given certificates upon request of the schools.

#### **SOME CONCLUDING STATEMENTS**

Since its inception in 1991, the SAAP project has expanded and presently includes Japan, Korea, Papua New Guinea, and most recently, China. Four development workshops held in the past produced and finalized eleven teaching-learning units, namely: Drinking Water, What Do You Eat, Energy At Home, The Impact of Global Warming, Renewable Energy, Tropical Forests, Domestic Waste, Acid Rain, Disappearing Wetlands, Plants in Our Lives, and Diseases – Case, Care, and Cure.

In the SAAP Project one finds collaboration from the educational and industrial sector institutions. It is a partnership of inestimable value in preparing today's learners for tomorrow's world which is what Science-Technology-Society is all about. Secondary schools here and abroad are welcome to accommodate SAAP in their science lessons to take advantage of information access and exchange for and among 14-17 year old students. Indeed, SAAP serves as a medium for global and borderless information flow, enhancing the teaching-learning process, for the benefit of learners – the center of concern in the teaching process who will be citizens of tomorrow.

To NAST, I am grateful for this rare privilege of being with this select audience and sharing a project that brings a global dimension to science education. SAAP can be one small but sure step in the DECS call for schools to go global.

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**POSTER ABSTRACTS  
PRESENTED IN DAVAO CITY**

***AGRICULTURAL SCIENCES DIVISION***

**THE USE OF PROGESTERONE RADIOIMMUNOASSAY  
TECHNIQUE IN DAIRY FARM MANAGEMENT AT  
SMALLHOLDER AND COMMUNAL LEVELS**

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Progesterone hormone is a key indicator of reproductive assessment in both humans and animals. This makes the hormone an ideal ligand for antibody production which serves as the basis for the development of immunoassay kits, such as radioimmunoassay (RIA) and enzyme-linked immunosorbent assay (ELISA) techniques. This report shows the practical application of progesterone RIA: liquid (LPRIA) and solid phase (SPRIA) techniques, for monitoring and evaluating ovarian function in dairy cattle managed under two farming systems namely, [1], at smallholder level in 3 pilot villages in Southern Luzon, Batangas (Bgy. Luyos, Tanauan), Laguna (8 villages in Sta. Cruz village in Pagsanjan) and Quezon (Bgy. Concepcion, Sariaya), and [2] at communal level in the Visayas province of Capiz (Bgy. Bailan, Pontevedra).

The technique is sensitive and reliable and has the advantage over other clinical methods as a tool for early pregnancy diagnosis in breeding management, especially for dairy cattle where milk samples can be collected on the day of breeding, and on the third week (days 19-23) after AI or natural mating, thus shortening the calving intervals, improving the reproductive efficiency of cows and the dairy industry of our country.



## COMPARATIVE NITROGEN, PHOSPHORUS, AND POTASSIUM CONTENTS OF COMPOSTED BANANA, GRAPEFRUIT, AND PINEAPPLE PEELINGS

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Mindanao, the Philippines' fruit basket, is apparently experiencing fruit waste disposal problems. Utilization of composted fruit peelings as organic fertilizers attempts to solve such problems.

"Cardava" banana (*Musa paradisiaca*), grapefruit (*Citrus paradisi*), and pineapple (*Anana comosus*) peelings were gathered, weighed, soaked in water, chopped and spread on dried wide leaves, and piled alternately with Harzianum rifai activator and chicken manure to hasten decomposition. After a month, the composted materials were dried and analyzed for nitrogen, phosphorus, and potassium using modified Kjeldahl, volumetric, and flame photometric methods, respectively.

Chemical analyses show nitrogen contents of 0.88, 0.92 and 1.07 percent for the dried pineapple, banana, and grapefruit composts, respectively. Phosphorus contents (as  $P_2O_5$ ) are 3.91, 3.87, and 3.84 percent, listed in the same order. Those of potassium (as  $K_2O$ ) are 3.19, 3.21, and 3.26 percents. Grapefruit contains significantly higher N and P.

Findings reveal that P and K levels of all three composts are comparable with such organic fertilizers as animal manures, but N is relatively lower. Average farm manure consisting of 70 percent moisture contains 0.5 percent nitrogen, 0.25 percent phosphoric acid, and 0.6 percent potash.

## DEVELOPMENT OF A FARM-LEVEL DRYER

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A simply designed recirculating dryer was developed suited for farm-level operation. It was fabricated in Tacurong, Sultan Kudarat, and tested to determine

its performance. Unique in its design is the bigger drying chamber with a simple grain flow mechanism. With wet paddy as test material, the prototype has a capacity of 5 metric tons with drying capacity of 91.53% and relatively low drying cost of about P 9.93/cavan utilizing kerosene pot burners as source of heat. A commercial model fabricated by an experienced dryer is recommended to further improve its performance.

**EFFECTIVENESS OF *Nerium indicum* MILL.  
AS INSECTICIDE TO HOUSE PESTS *Blatta orientalis*  
(COCKROACHES)**

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Chemical control of household pests such as cockroaches (*Blatta orientalis*) is costly and hazardous to health as well as the environment. This study was conducted to determine whether the sap of adelfa (*Nerium indicum* Mill.) bark extracted by boiling in water for 35 minutes could be effective as insecticide. The extracts obtained with different weights of air dried adelfa bark to a constant volume of water (Set A treatments), were tested including extracts where kerosene ( $C_nH_{2n}$ ) (Set B treatments) and alcohol ( $C_2H_5OH$ ) (Set C treatments) were added. The tests were conducted in a laboratory using Completely Randomized Design as a statistical tool.

Results showed that sap of adelfa bark extracted in the proportion of 30, 20, and 10 g per 200 mL water is as effective as the commercial household insecticide used as reference standard. The addition of 25 mL of kerosene to 100 mL of extracts resulted in higher effectivity. Alcohol as additive to the extracts likewise increased effectivity.

Adelfa bark extract could be an alternative insect pest control material which could be prepared easily involving a very minimal cost. Alternative sap extraction procedures should be devised and possibilities of using the extract as a general insect control material should be explored. Caution should be undertaken to protect the health of the processor and the end user.

## **TERATOGENICITY OF ORGANOPHOSPHATE PESTICIDE ON *Tilapia nilotica***

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Since the ban on organochlorines, organophosphates have been extensively used in agriculture as pesticides in order to increase crop production. However, their indiscriminate use has resulted in the presence of their residues in rivers and lakes. This study evaluates the effect of commercial grade malathion S-[1,2-di(ethoxycarbonyl) ethyl] dimethyl phosphorothiolothionate EC 57 on *Tilapia nilotica* embryos. Results of this study would provide (1) baseline data on pesticide effects on nonpests, particularly on fishes, and (2) information for government agencies that will guide them in the formulation of policies on pesticide use.

Day-10 post hatching embryos that were exposed for 60 days to sublethal doses of 0.3 mg/L malathion exhibited various aberrations. Brain defects included nuclear blebs, swollen short-stranded endoplast, and degranulated endoplasmic reticulum. The cytoplasm exhibited electron-light background and extensive vacuolations. The gonads of pesticide-treated embryos showed delay in ovarian differentiation and cavitation in older embryos. The notochord lost its secondary sheath and was significantly larger than that in the control. The gills showed epithelial lifting and mucus secretions.

## **UTILIZATION OF SELECTED TREE SPECIES AS HEDGEROWS FOR ROOTCROPS: A STRATEGY FOR UPLAND DEVELOPMENT IN MINDANAO**

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One of the most promising agroforestry technologies for upland development today is the employment of hedgerow intercropping or the alley cropping scheme. Henceforth, utilization and evaluation of the potentials of selected tree species as hedgerows for agricultural crops particularly in the uplands are necessary.

Three leguminous trees (*Flemingia congesta*, *Gliricidia sepium*, and *Sesbania sesban*) were evaluated as hedgerows for gabi and camote in a cogonal upland from 1989 to 1992. The experiment was laid out in split-plot design in RCBD with three replicates.

Results showed that the hedgerows did not significantly affect the growth and yield of gabi and camote in the first cropping but did so in the second cropping. *Flemingia* ranks first in terms of influence on the performance of gabi and camote which was followed in descending order by *Gliricidia* and *Sesbania*. The significant contribution of each hedgerow species to the nutrient content of the soil particularly OM, P, and K is the main reason why each hedgerow had significantly enhanced the growth and yield performance of both the alley crops and the hedgerows themselves, mainly through nitrogen fixation and nutrient cycling. *Gliricidia* exhibited the highest overall fresh weight herbage yield (84.87 t/ha) which was followed closely by *Flemingia* (81.28 t/ha); *Sesbania* yielded 47.66 t/ha. Nonetheless, in terms of dry weight herbage yield, *Flemingia* (28.58 t/ha) outyielded *Gliricidia* (21.22 t/ha) which in turn significantly differed with *Sesbania* (14.30 t/ha).

## PRODUCTION OF DIETARY FIBER FROM BAGASSE

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Dietary fiber was isolated from whole bagasse and bagasse pith by prehydrolysis with water and digestion and multi-stage bleaching with sodium hydroxide and calcium hypochlorite.

Isolated dietary fiber had 55-56% alpha cellulose, 43-44% hemicellulose, 0.4-0.6 lignin, and minimal residues of sodium, chloride, and calcium.

Recovery from the test runs was 19-33% from whole bagasse and 29-38% from bagasse pith. Pure dietary fiber from whole bagasse was 99.6% while that from bagasse pith was 99.4%.

The cost of chemicals to isolate dietary fiber from whole bagasse was higher than that from bagasse pith.

**TAPPING OF ALMACIGA (*Agathis philippinensis* WARB.)  
FOR SUSTAINED PRODUCTIVITY OF THE TREE:  
THE PHILIPPINE EXPERIENCE**

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Tapping almaciga is a veritable economic activity. The resin obtained from the tree is called almaciga resin or Manila copal. Although regarded as a minor forest product, it is one of the leading dollar-earners for the country. It is used in the manufacture of varnishes, lacquers, soaps, paints, printing inks, linoleum, plastic, water-proofing materials, and paper sizing. It also can be used as incense in religious ceremonies, as smudge for mosquitoes, as torches, and for kindling fire. However, traditional methods of collection like deeptapping, overtapping, and frequent re-chipping, cause death of many standing trees. Considering the detrimental effects caused by such traditional methods of collection, a set of scientific techniques was developed at FPRDI. This has been introduced to and adopted by the almaciga resin licensees, farmers, and out-of-school youths in various parts of the country. This paper covers two parts: (1) the tapping practices of almaciga in the Philippines; (2) biological considerations in almaciga tapping essential for sustained resin production.

**THE PROPAGATION OF MANGO PLANTING MATERIALS  
USING SINGLE-STEM MODIFIED INARCHING  
AND CLEFT GRAFTING**

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The study was conducted at the University of Southeastern Philippines, Apokon Campus, Tagum, Davao del Norte, to discover modifications in propagating mango and to evaluate the survival rate as well as the economic advantages of each method. The data on the survival rate were statistically analyzed using the Variance in RCBD.

The result of the experiment was significant at the 1% level of probability but single-stem modified inarching and cleft grafting (control) did not show any significant difference. The single-stem modified inarching and cleft grafting methods were compared and the advantages were more on the single-stem modified inarching.

Based on the result of the study, it is therefore concluded that modified inarching can be one of the methods in propagating mango. The use of this method is recommended when the nursery is near the source of scions and far from the farm where mango production will be established.

## **GROWTH AND DEVELOPMENT OF MACAPUNO EMBRYOS FROM DWARF X MAKAPUNO HYBRIDS IN MODIFIED Y3 MEDIUM**

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A modified Y3 medium formulation proved to be suitable for the growth of macapuno embryos from dwarf x macapuno hybrids. Fully mature embryos grown in the said medium had fast growth and development. An inch shoot with initial root growth could be attained in four-week cultures. After two to three passages in a four-month period, seedlings were usually ready for potting.

The seedlings grown in the modified Y3 medium were robust at the time of potting with 3 to 5 leaves and well-developed, usually profuse, root systems. Survival of the seedlings in pots was more than 80%.

## **RESPONSE OF COCONUT TO RECYCLING OF COCONUT CROWN RESIDUES AND CIRCLE WEEDING**

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The study was conducted from 1986 to 1994 at the Davao Research Center of PCA to assess the effect of recycling coconut crown residues as organic fertilizer and of circle weeding on the yield and solid properties.

Observations revealed that coconut crown residues alone could not increase coconut production. But when it was combined with Cl (crown residues + Cl) a significant effect was noted starting the second year which was comparable with the inorganic fertilizer application of ammonium sulfate + Cl. This makes possible the substitution of coconut crown residues for ammonium sulfate as N source. Also, the use of coconut crown residues either with or without Cl increased soil pH and K content of the surface soil although these changes were not statistically significant.

The economic situation of 1994-1995 of the combined coconut crown-NaCl application (T5) indicated highest net benefit of P148.46 per tree/year or P23,159.76 per ha/year.

Removal of weeds around the base of each coconut tree did not significantly affect coconut yields though some 10-29 percent increases in copra production were noted in certain years which warrants its continued practice for sanitation purposes.

## **A GENETIC MAP OF JAPONICA RICE BASED ON DNA MARKERS\***

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The limited genetic diversity among japonica rice cultivars has precluded their use in map construction using molecular markers. Rice molecular maps were generated using intersubspecific and interspecific crosses. However, reports indicate that majority of Philippine traditional cultivars are japonicas. Furthermore, IRR's new plant type is genetically based on japonicas. We present the first japonica rice molecular map based on a tropical X temperate japonica cross (Labelle X Italica Livorno). This map consists of 125 random amplified polymorphic DNAs and 18 restriction fragment length polymorphisms assayed on 118 F<sub>2</sub> plants. Total map length is 970.9 Kosambi cM with average marker spacing of 7.6 cM and markers on

\*Best poster paper award in the Agricultural Sciences Division.

all chromosomes. The percentage of markers on the least marked on the 12 rice chromosomes (chromosome 10) is significantly greater than in other rice molecular maps, but fewer markers were identified on chromosomes 1 and 2. Results indicate that RAPDs are useful for linkage map construction in japonica rice. The japonica map can be used as a framework for mapping studies, in understanding the genetic differentiation of tropical and temperate japonicas, and in identifying and tagging genes in the japonica subspecies.

**VIRULENCE OF RARE BACTERIAL LEAFBLIGHT**  
*(Xanthomonas oryzae pv oryzae)*  
**HAPLOTYPES AGAINST PHILIPPINE VARIETIES**

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Rare haplotypes of bacterial leaf blight pathogen were identified using RFLP DNA fingerprinting from among 286 isolates collected in Northern and Central Luzon. Two probes (IS1113 and IS1112) were used to detect rare isolates based on the frequency of their occurrence. Using the standard cultivar for pathogenicity, the rare isolates were grouped into the different prevailing Philippine races. Five rare haplotypes that are classified as races 2, 3, 5, 6, and 8 were tested for virulence against 53 Philippine-bred high-yielding varieties. Shifts from less virulent to more virulent forms and vice versa were observed. A strong shift to a more virulent form was noted in a rare isolate of race 6.



**RESPONSE TO INTEGRATED SOIL FERTILITY  
MANAGEMENT (ISFM) OF HYBRID COCONUT  
GROWN IN DIFFERENT AGRO-CLIMATIC CONDITIONS  
OF MINDANAO:  
I. POLONULING, SOUTH COTABATO;  
II. BALIANGAD, MISAMIS OCCIDENTAL;  
III. GUISAO, ZAMBOANGA CITY;  
IV. COGON, DIPOLOG CITY I**

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Four on-farm fertilizer trials were conducted in different locations of Mindanao from 1986-1994 to assess the effect of organic fertilizers and their combinations on ISFM on the growth and yield of hybrid coconut.

The application of high rates of inorganic fertilizers and combined inorganic fertilizers produced significantly higher number of leaves and living fronds from the second to the third years of fertilizing. With low and high rates of organic fertilizers, significant increases in nut yield by 141 to 168% were noted over the unfertilized palms and in copra production by 109-148%. The organic plus inorganic fertilization also produced an appreciable 67-189% nut yield increase and 69-200% copra increase over unfertilized palms. Very likely, yield improvement was due to the correction of N and Cl deficiencies of palms.

Results obtained clearly showed that nitrogen and chloride are major yield-limiting nutrients in Mindanao coconut farms and fertilization is needed to increase productivity in the region for the Philippines to be globally competitive in the world's vegetable oil market.

**EFFECT OF COCONUT WATER AND POLYETHYLENE  
BAGS ON THE STORAGE OF LANZONES**

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The chemical and quality changes of lanzones fruit during storage using coconut water as dipping solution and polyethylene bags (PEB) with or without

diffusion holes and packaging material were determined to provide some basic information on the chemical constituents and quality of the fruits. This was conducted at the Postharvest Laboratory of the Department of Horticulture, College of Agriculture, University of Southern Mindanao (USM), Kabacan, North Cotabato from September 28 to October 5, 1995.

Percent cumulative weight loss of the fruit increased gradually from the 1st day to the 7th day of storage under modified atmosphere storage. A rapid increase in weight loss, on the other hand, was observed in fruits stored at ambient conditions. Total soluble solids (TSS) increased while titratable acidity (TA) decreased.

Lanzones fruit stored under ambient conditions last only for four days after harvest. In modified atmosphere storage, the fruit remain in good condition for one week.

Results indicated that as the fruit is stored, weight loss increased gradually due to the metabolic processes taking place within the fruit, i.e., respiration and transpiration.

A follow up study should however, be conducted to further assess the chemical changes in the fruit during storage.

## **EFFECT OF LIGHT INTENSITY ON THE GROWTH OF DURIAN SEEDLINGS**

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The effect of the light intensity on the growth of durian seedlings in terms of plant height, leaf number and size, stem diameter, petiole length, and internode length was evaluated from December 1994 to April 1995. The experiment was conducted at the University of Southern Mindanao Agricultural Research Center (USMARC), Kabacan, North Cotabato.

Durian seedlings were transplanted in black 7" x 14" polyethylene bags filled with a mixture of 2:1 ratio of soil and sand. After transplanting, the seedlings were maintained under the shade (nipa shelter) for three weeks and were then transferred under a single layer nylon mesh (2300 foot candles light intensity). The rest of the seedlings were transferred under three layers of nylon mesh (light intensity was reduced to 50%). The height of the shade was approximately six feet from the ground. Seedlings were arranged in a randomized complete block design (RCBD) in three replications.

Results of the experiment showed that significantly thinner leaves were obtained under conditions where the light intensity was reduced to 50%. Plant

height, internode length, stem diameter, leaf number, and number of branches were not significantly affected by light intensity. Petiole length and leaf size on the other hand, were significantly longer and bigger, respectively, when the seedlings were grown under conditions where the light intensity was greatly reduced.

## **BIOLOGICAL SCIENCES DIVISION**

### **CYTOGENETIC AND MOLECULAR ANALYSES OF *Oryza sativa* L. x *O. officinalis* WALL. ex WALL. DERIVED PROGENIES**

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Cytogenetic and molecular techniques were used to characterize *Oryza sativa* L. RFLP (MAAL), *O. officinalis* (CC), their F1 hybrid (AC), and backcross progenies. Hybrid nature of the F1 was confirmed by the presence of 24 chromosomes predominantly univalents and by the mitotic abnormalities causing male sterility. Limited chromosome pairing in the F1 and pattern of genomic DNA hybridization on Southern blots indicated little homology between *sativa* and *officinalis* genomes.

Cytogenetic analysis of BC1F1 progenies revealed their allotriploid nature (2n=30, AAC) except for three plants which behaved like the F1 in terms of chromosome number and isozyme and RFLP patterns. Embryo sac analysis in these plants did not show evidence for apospory or diplospory types of apomixis. Isozyme and RFLP techniques identified the extra chromosome(s) as well as introgressed alleles of *O. officinalis* in the MAAL and other hyperploids (2n=26, 28, 30, 34, 35). However, the two disomic progenies (2n=24) did not show

introgression for isozyme or RFLP alleles of *O. officinalis*. Isozyme and RFLP patterns indicated chromosome 6 as the extra chromosome in the MAAL.

### **SPORE CULTURE OF *Asplenium nidus* L.**

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*Asplenium nidus* L. is an economic fern which is locally known as bird's nest or pakpak-lawin. It is used as an ornamental and for orchid potting.

This study was conducted to determine gametophyte and sporophyte development of *Asplenium nidus* in culture media through spore culture. The spores germinated 10-20 days after sowing. Prothallial development was of the *Adiantum* type. Formation of sporophytes occurred 51-60 days in culture. The sporophytes were transplanted in potting media and were grown in the CAS Fernarium.

### **EFFECT OF NaCl AND NEUTRAL OSMOTICA ON THE LEAF ELONGATION RATE (LER) OF RICE\***

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The objective of the study was to investigate the response of leaf elongation rate (LER) of rice shoots to NaCl or osmotica using young seedlings grown under axenic conditions. A method of producing an axenic whole plant inside a test tube from germination until the 3<sup>rd</sup> leaf stage with optimum growth was developed. To determine if NaCl has an osmotic effect that can be observed for several days, the LER of axenic Nona Bokra seedlings grown in NaCl or mannitol at isoosmotic concentrations, i.e., 300 mOs to 2 mOs, which also resulted in higher LER of

\*Best poster paper award in the Biological Sciences Division.

seedlings in 300 mOs of NaCl or mannitol within 5 d suggests that the osmotic effect of NaCl can last for several days and not only hours. Moreover, the recovery of NaCl-stressed Nona Bokra plants within 24 h after the concentration was reduced from 300 mOs to 2 mOs, which also resulted in higher LER than the control within 2 d, suggests that the growth reduction within 5 d was due to an osmotic effect. Furthermore, the same decrease in LER at isoosmotic concentrations of NaCl or neutral osmotica, e.g., raffinose or melibiose, within 2 d indicated those growth reduction during salinity can be partly explained by the osmotic effect of NaCl.

It is known that uninhibited influx of salts accounts for the long-term toxicity of even low external salinities in rice and that ways to reduce or eliminate excessive ion entry should be incorporated for the development of salt-tolerant rice varieties. Results from this study suggest that since at high salinity, low osmotic potential of the medium can also reduce growth, then, screening for "osmotic shock" resistant rice varieties, e.g., through osmotic adjustment, during the initial stages of salinity should also be considered as a component in the development of salt tolerant rice varieties.

## **THE ECOLOGY OF THE MIGRATORY LOCUSTS, *Locusta migratoria manilensis* MEYEN**

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The migratory locust is an endemic pest of the Philippines. Infestations have been recorded as early as the 1500s by Augustinian friars. However, until now there is a dearth of information as far as the ecology of this pest in the Philippines is concerned.

Recent findings regarding flora and fauna associated with locusts in breeding areas; updated morphometrics of solitary and gregarious phases; new behavioral observations; correlates of soil properties and egg-laying; and recent factors about migration of locusts in Central Luzon and other parts of Luzon are discussed.

## A SURVEY OF BOVINE, BUBALINE, AND SWINE SARCOCYTOXIS IN THE PHILIPPINES

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In a survey conducted during the months of January to December, 1994, muscle tissues in twelve out of twenty-two slaughtered carabaos, ages 8-17 years, and obtained from the Food Terminal, Inc., Abattoir in Laguna showed numerous white and creamy elliptic-shaped soft bodied macrocysts in the throat muscles. Microscopic examination of the throat and cardiac muscle tissues revealed the presence of fusiform-shaped microcysts. Our observations are consistent with previous reports incriminating *Sarcocystis fusiformis* as the most important etiologic agent of bubaline sarcocystosis in the country. In a survey of bovine sarcocystosis in muscle tissues of imported Australian cattle (Brahman Breed) and native cattle obtained from various slaughter houses in Manila and suburbs, prevalence rates of 17.0% (98/577) and 3.2% (1/31) were noted, respectively. Sarcocysts were predominant in skeletal muscles and to a lesser extent in cardiac, esophageal, and diaphragm muscle tissues. Light microscopic examination of sarcocysts morphology suggests *Sarcocystis cruzi* (= *Sarcocystis bovis*), and *Sarcocystis hominis* (= *Sarcocystis bovi-hominis*) or *Sarcocystis hirsuta* (= *Sarcocystis bovis-felis*) as the likely etiologic agents of bovine sarcocystosis in the country. Of the 225 swine examined, only muscle tissues from a 6-month old swine revealed very young sarcocysts (microcysts). A review of available documented studies on sarcocystosis suggests that, to date, our findings may represent the first data on the prevalence of bovine and swine sarcocystosis in the Philippines.

**ALLOZYME VARIATION AMONG GEOGRAPHICALLY  
ISOLATED POPULATIONS OF *Apis cerana* F.  
IN THE PHILIPPINES**

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Genetic variabilities within and between natural populations of *Apis cerana* F. from Bicol, Quezon, Laguna, Batangas, Mindoro, and Palawan were compared using horizontal starch gel electrophoresis. The frequency of occurrence of the allozyme esterase (Est), malate dehydrogenase (Mdh), isocitric dehydrogenase (Idh), and alkaline phosphatase were determined. In terms of presumptive allelozymes, S (slow), M (moderate), and F (fast) forms were noted. Polymorphism was observed in esterase in all areas showing the three genotypes at the Est locus. Malate dehydrogenase, also with three forms, was polymorphic except in Mindoro. Isocitric dehydrogenase was polymorphic in three areas (Bicol, Laguna, Mindoro) while alkaline phosphatase polymorphism was observed only in Palawan, Batangas, and Mindoro). Both enzymes showed only two genotypes as their loci.

Populations within each area showed high degrees of genetic identity with low variation in their types of alleles. The genetic distances were, therefore, quite low. Comparison of the genetic identities and distances between areas, however, showed significant differences.





## **HEALTH SCIENCES DIVISION**

### **CINNAMON BARK OIL AS AN ANTIBACTERIAL AND ANTIFUNGAL AGENT**

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Preliminary antibacterial and antifungal screening analysis of the oil from the bark of *Cinnamomum mercadoi* using the paper disk diffusion method, showed strong inhibition against the reference strains: *Staphylococcus aureus* Atcc 25923, *Candida albicans*, and *Fusarium moniliforme*. However, the oil exhibited moderate inhibition against *Escherichia coli* ATCC 25922.

Cinnamon bark oil, tested against forty-five common clinical pathogens isolated from the blood, throat, sputum, stool, and urine, strongly inhibited these pathogens. *E. coli* from urine was moderately inhibited.

Results suggest that cinnamon bark oil has a strong potential as an antibacterial agent against skin and urinary tract infections; and is a very potent antifungal agent. Furthermore, there was no dermatological adverse effect when the oil was tested using albino rabbits.



***MATHEMATICAL, PHYSICAL, AND  
ENGINEERING SCIENCES DIVISION***

**SOLID WASTE DISPOSAL SITE SELECTION USING IMAGE  
PROCESSING AND GEOGRAPHIC INFORMATION  
SYSTEMS (GIS) TECHNIQUES**

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This research aims to demonstrate the potential and efficiency of using Geographic Information Systems, GIS, in selecting optimum sites for the storage of solid waste. The study area selected was Cagayan de Oro City and its vicinity in Misamis Oriental as the required data in this area are readily available. First, the requirements in selecting landfill sites are identified according to government regulations for sound environmental management. The relevant environmental and cultural data are then collected from analogue maps, satellite images, aerial photographs, and field surveys. As soon as these data are converted to digital form, they are analyzed using GIS functions (e.g., proximity operation, Boolean operation) to produce a final map showing the areas meeting all the criteria or the optimum sites for solid waste disposal.

## EVALUATION OF A CORN POLLEN-SPECIFIC PROMOTER USING THE *GUS* A GENE IN TRANSGENIC RICE

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U.S.A.*

The narrow source of cyto sterility limits the use of hybrid breeding in other climatic locations and increases the probability of insect and disease epidemics in the cytoplasmic male sterile lines produced. Genetic engineering can be an alternative method for producing plant hybrids. Genes and promoter sequences specific to anther/pollen-specific can be identified to direct inducible transcription and translation of proteins that would render the plant male sterile.

*Zmg 13* is a mature pollen-specific gene that is expressed at the time of microspore mitosis and continues to accumulate as the pollen matures. In attempts to develop a genetic engineering system whereby the sterility and fertility of transgenic rice lines produced can be controlled, the activity of the *Zmg 13* promoter was considered for evaluation. To determine if the corn pollen-specific promoter would function in rice, a polyethylene glycol-mediated transformation method was used to transform rice protoplasts with the *Zmg 13* promoter starting from the -260 position placed in front of the  $\beta$ -glucuronidase gene (*gus A*). Cells were co-transformed with the *bar* gene, which confers resistance to phosphinothricin (PPT), the active ingredient in the broad spectrum herbicide Basta. Transgenic plants that were resistant to Basta and expressing *GUS* were regenerated after selection in PPT at a selection efficiency of 86.6% and a co-transformation efficiency of 72%. *GUS* expression in the mature pollen was found to be influenced by the number of integration events and the physiological age of the pollen. Minimal integration events were found to yield *GUS* activity approaching 50% of the mature pollen – the expected results based on the hemizygous condition of the plants. Somatic tissues did not express *GUS*. The results indicated that the corn pollen promoter functions in rice and drives the expression of the *gus A* gene in the expected developmental and tissue/cell-specific manner. This is the first report of a monocot pollen-specific promoter isolated from one species, corn, and expressed in another monocot, rice, in a developmental and cell-specific manner.

## **STUDIES ON THE PROPERTIES OF PLASTIC AND CRYSTAL SCINTILLATORS**

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and LEAR ROMAGUERA**  
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A piece of scintillating material attached to a photomultiplier tube make up a system of scintillating detectors. When a voltage is applied to the cathode of the phototube, detectable signals can be observed and measured with a large-bandwidth oscilloscope. Comparative studies are done on the properties of a plastic scintillator detector and an inorganic crystal scintillating detector, which in our case is NaI(Tl) crystal. The following properties are observed and measured: rise time, fall time, decay width, counter plateau, and dark current.

Using a CAMAC system for spectroscopy studies, the spectra for Cs-137 and other gamma-emitting sources are obtained and compared for plastic scintillators and the NaI(Tl) detector.

## **INVESTIGATIONS ON THE CAMAC DATAWAY OPERATIONS**

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and MEINHART MOSQUEDA**  
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An acronym for Computer Automated Measurement and Control, the CAMAC, is an internationally accepted group of standards that fully define the modular-real time interface concept for configuring high-performance data acquisition and control systems. The essential components of the CAMAC system are a crate and plug-in type modules. The crate is composed of slots or stations into which the modules are inserted. At the rear of the module is a card-type connector which mates with a corresponding connector at the back of the slot. This connector contains contact points which couple the module to a series of parallel wires running along the backplane of the crate linking each of the stations. This series of wires is known as the dataway and is the essential feature of the CAMAC system. In modern terms, the dataway would be known as a backplane bus. All communications within a CAMAC crate are overseen by a special module known as the crate controller which is inserted in the last two slots of the crate.

The dataway is the nervous system of the CAMAC system. Communications between modules, crate controller, and host computer are made via the dataway. The dataway signals may be classified into six categories: control, addressing, timing, data, status, and commands. Using a 12-slot CAMAC crate and a few CAMAC modules, investigations were done to determine the relative timing of these signals. The minimum cycle times for one complete CAMAC operation for these types of signals were determined. These data are of crucial importance in the real-time data acquisition algorithms used in any experiment utilizing the CAMAC.

**DEVELOPMENT OF AN ENZYMATIC TOXICITY TEST  
WITH SELECTED PHYLLOPOD SPECIES  
(Crustacea: Anostraca and Cladocera)\***

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This paper presents the results of a study aimed at the development of a rapid toxicity screening test for routine detection and quantification of toxic hazards. It is probably the very first attempt to explore the potential of using a typical biochemical criterion – enzymatic inhibition – as test criterion for bioassays with *Daphnia magna*, *Artemia franciscana*, *Thamnocephalus platyurus*, and *Streptocephalus proboscideus* carried out in vivo. The response can be visualized under UV as the presence or absence of fluorescence in the test organism using fluorogenic or chromogenic indicators after a 1-hour exposure to different concentrations of the toxicant.

The results of electrophoretic analyses to elucidate the fundamental mechanisms behind the enzymatic inhibition criterion showed various degrees of inhibition or induction attributed to the specific mode of action of the chemicals. Comparisons between the results of conventional toxicity tests and the 1-hour enzymatic inhibition tests (1h EIT) on pure chemicals and compounds showed correlations ( $r^2$ ) ranging from 0.87 to 0.98 depending on the species. The study also showed the utility of the 1h EIT as a toxicity screening test for complex environment samples such as solid waste leachates, monitoring well waters, effluents, and various

\*Best poster award in the Mathematical, Physical, and Engineering Sciences Division.

classes of detergents. The sensitivity and comparability of the results of the 1h EIT to other conventional bioassays and the rapidity with which it generates results indicate its potential as a useful component in a battery of toxicity tests.

**INHIBITION OF ACTIVITY OF CELL WALL  
DEGRADING ENZYMES AND GROWTH OF  
BACTERIAL WILT PATHOGEN  
(*Pseudomonas solanacearum* E.F. SMITH)  
BY FLAVONOIDS**

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Bacterial wilt remains to be one of the most destructive bacterial diseases of plants including tomato. Whereas cell wall degrading enzymes, such as polygalacturonase and cellulase, were found to accumulate in virulent cultures of the pathogen, phenolic compounds have been shown to exhibit enzyme inhibitory and antifungal activities and thus serve as defense-mechanisms of plants against infection. This study presents the effect of flavonoids on the activities of the exocellular polygalacturonase and cellulase enzymes and on the growth of *Pseudomonas solanacearum*.

Polygalacturonase was significantly inhibited by the seven flavonoids tested and *p*-coumaric acid, a simple phenolic compound. The most effective inhibitor was quercetin, a flavonol with  $IC_{50}=7\mu M$  while the least effective was apigenin, a flavone with  $IC_{50}=175.92\mu M$ . Similarly, cellulase was also significantly inhibited by the seven flavonoids and *p*-coumaric acid. However, the most effective inhibitor was taxifolin with  $IC_{50}=25.0\mu M$  and the least effective inhibitor was catechin with only 77.18% inhibition at 100  $\mu M$ . The potencies of the inhibitors against the two enzymes were found to be variable.

The growth of *Pseudomonas solanacearum* was inhibited by the flavonoids. The average CFU/mL was significantly reduced by 1.4 to 2.7x as the concentration of quercetin and taxifolin increased. Colony size was reduced and morphology changed from smooth to rough. Quercetin at 25  $\mu M$  was found to be a better bacteriostatic agent than taxifolin at 100  $\mu M$  concentration with an average CFU/mL of  $7.63 \times 10^6$  and  $9.13 \times 10^6$ , respectively, compared to control which had  $>2.5 \times 10^7$  CFU/mL.



## **HANDMADE SIMPLE CELLS**

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Many students consider that the principles of operating cells and batteries are difficult to learn. This presentation aims to disprove the said preconception or misconception. Generally intended for physics and science teachers, the presentation focuses on: advanced testers, how to make a melody tester, structure of a cell, breaking a cell, making a melody battery checker, making 35-centavo cells, and improving simple cells.

## **SENSITIVITY ANALYSIS IN ALPHA FACTOR ANALYSIS AND ITS NUMERICAL APPLICATIONS**

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There are several sensitivity analysis procedures which have been considered by Tanaka and Odaka (1989) to investigate the phenomena of how a small change of data affects the outcome of factor analysis. Among them are those for principal factor analysis (PFA), maximum likelihood factor analysis (MLFA), and least square factor analysis (LFSA). In this study, we apply a similar method to show the sensitivity on alpha factor analysis. (AFA; Kaiser and Caffrey, 1965) which is based upon the psychometric concept of generalizability. The basic idea of AFA is to determine the common factor  $F_j$  in such a way that they have maximum correlation with the corresponding universe common factors. Some examples are explained to illustrate the present procedure and a comparison is made in particular with the case of PFA and MLFA.

## **POLYPHENOLS IN COOKING BANANA – CHANGES DURING RIPENING AND COOKING AND RELATION TO ASTRINGENCY**

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Table banana cultivars of Lakatan, Latundan, and Bungulan had low levels of flavan-type or vanillin-positive polyphenols (0.10 to 1.96 mg catechin equivalents (CE/g) and also low levels of protein-precipitable polyphenols (0.05 to 0.59 mg tannic acid equivalents (TAE/g). Cooking banana cultivars, Saba and Gubao, had 10-fold and 4- to 10-fold higher level of vanillin – positive and protein-precipitable polyphenols.

The levels of phenolic compounds decreased by 6- to 7-fold in the pulp during ripening of banana cv Pundol which was accompanied by loss of astringency and significant lowering of degree of polymerization from 7.27 to 6.21. Gel permeation chromatography of methanol extracts of unripe and ripe pulp of cv Pundol gave elution curves of similar molecular weight range.

When green mature (unripe) Pundol pulp was cooked, flavan-type phenolics increased from 2.79 to 4.56 CG/g while protein-precipitable polyphenols decreased from 2.14 to 0.65 mg TAE/g. There was loss of astringency and a significant decrease in the degree of polymerization from 7.27 to 3.87 upon cooking of unripe Pundol pulp.

However, cooking the yellow mature ripe pulp of Pundol resulted in a significant increase of total phenols and protein-precipitable polyphenols as well as the degree of polymerization from 6.21 to 9.70 and the appearance of astringency. Gel permeation chromatography revealed the formation of a large molecular weight component in the cooked sample.

## **PRODUCTION OF BETA-CAROTENE FROM *Rhodotorula glutinis***

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The requirement of *beta*-carotene for nutrition and health has attracted research on the development process for its production. The effects of ammonium sulfate, yeast extract, and sugar concentrations on the *beta*-carotene yield from *R. glutinis* were studied on a batch fermentation process. Multiple linear regression analysis was used to determine *beta*-carotene production as a function of ammonium sulfate, yeast extract, and sugar concentration.

Results show that three components used in a fermentation medium had very high significance on the *beta*-carotene yield. Yeast extract had a linear effect, while parabolic curves were obtained for ammonium sulfate and sugar concentrations. The interaction effect of these components was also highly significant on the *beta*-carotene yield. The contour diagrams using the response surface analysis illustrated the optimum fermentation components on *beta*-carotene yield. The concentration of *beta*-carotene was 9 mg/L at the optimal levels of 3 g/L ammonium sulfate, 9 g/L yeast extract, and 50 g/L sugar.

## **CHEMISTRY RESEARCH IN THE PHILIPPINES FROM 1905 TO 1982**

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A total of five hundred sixty-six research projects done in thirteen institutions in the Philippines from around 1905 to 1982 were examined by studying either the summary or the abstract or the outline or sometimes only the title of the research projects. The trends in research topics, area of specialization of the institutes, the universities, and the researches were analyzed, based on the research output. The frequency with which the topics were taken as subject of research was plotted to determine the "popularity" of research topics. The research topics are functions of the nature of the research institute and the field of specialization of the researchers in the universities. Other factors affecting choice of research topics are also discussed. To the extent that the available data allow, thoroughness or follow-through for selected topics was also studied.

## **MOVEMENT OF ATRAZINE IN INTACT AND PACKED SOIL COLUMNS**

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This study attempts to understand the factors affecting the downward transport of atrazine in soils. The movement of atrazine was studied in intact and packed columns of two soils (Pratt loamy and Smolan silty clay loam). Intact columns were collected in PVC pipes while packed columns were constructed by filling plexiglass tubes with sieved (2 mm) soil materials. Atrazine was applied on the surface at the rate of 40- and 58 mg a.i. L<sup>-1</sup> for Pratt and Smolan soils, respectively. The soils were leached with distilled water and leachates were collected every 48 h. Breakthrough curves were constructed by plotting relative concentration against pore volume (PV). In Pratt soil, early breakthrough (0.5 PV) of atrazine occurred in both intact and packed columns indicating unrestricted liquid and solute flow through loose and porous soil matrices. In Smolan soil, early breakthrough of atrazine occurred in intact (0.3 PV) but not in packed (2 PV) columns suggesting that atrazine moved preferential flow through macropores in intact columns and its transport was retarded in packed columns because the sieving and packing procedures eliminated the flow channels and sealed up the macropores. Results of the study have important implications on the management of chemicals for agriculture.

## **WATER QUALITY OF THE COGON RIVER: CURRENT STATUS**

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The water quality of the river was determined during a fifteen-month period from September 1994 to December 1995. Baseline data on water quality parameters, namely D.O., pH, temperature, salinity, density, conductivity, transparency,

chlorides, carbonates (hardness), total dissolved solids, and MPN coliform bacteria were gathered to assess the current status of the river.

Litter analysis using a square plot method was conducted in four stations along the embankment of the river. Findings showed that the river is not very polluted. Based on monthly variation per station of the water quality parameters, it is postulated that the Cogon River has the inherent capacity for self-purification.

Recommendations for conservation and sustainable maintenance of acceptable qualities of the river water are proposed.

## AN ANTIMUTAGEN FROM *Cucurbita maxima* DUCHESNE FLOWERS

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The antigenotoxic constituent of squash flowers was isolated by a Micronucleus Test-guided fractionation and purification.

Isolate SQFwB2D from the chloroform extract of squash flowers is the most antigenotoxic isolate. It decreased the mutagenicity of tetracycline by 64.7% at a dosage of 100 mg/kg mouse. Statistical analysis using Kruskal Wallis One-Way Analysis of Variance by Ranks showed that SQFwB2D is different from the control group (tetracycline + corn oil) at  $\alpha=0.001$ .

GC-MD of isolate SQFwB2D shows 2 peaks at  $R_t=19.860$  (SQFwB2D-1) and 20.242 min (SQFwB2D-2) with relative peak heights of 16:1, respectively. Spectral analyses show that SQFwB2D-1 is 24 $\alpha$ -ethyl-5 $\alpha$ -cholesta-7trans,22-dien-3 $\beta$ -ol or spinasterol.

## **MUTAGENICITY STUDIES ON IPIL-IPIL SEED GUMS**

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Bulk extraction of ipil-ipil seed gum was done on whole seeds. The ipil-ipil seeds were ground using a blender. They were then placed in boiling water to disperse the gum. The crude gum was purified by fractional precipitation. Physicochemical and chemical studies showed that the gum exhibited properties similar to that of galactomannan from guar gum.

The results of the Micronucleus Test showed that the ipil-ipil seed gum is not mutagenic at dosages of 3 mg and 50 mg/kg mouse. At a dosage of 3 mg/kg body weight, the gum reduced by 57.2% the number of micronucleated polychromatic erythrocytes (MN-PCE) induced by the mutagen tetracycline. An increase in the dosage of the gum to 50 mg/kg mouse led to an 81.0% reduction in MN-PCE. Thus, ipil-ipil seed gum is antimutagenic.



## ***SOCIAL SCIENCES DIVISION***

### **AN INITIAL STUDY OF THE ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT OF THE IRISAN DUMPSITE**

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The study aims to present more concrete data on the effects of Baguio City's sole garbage dumpsite in Barangay Irisan on the water supply of low-lying communities. It also seeks to provide data on the economic benefits that the residents may be gaining from the dumpsite. These results will hopefully assist policymakers and other people concerned in dealing with the dumpsite relocation issue.

Results of physiochemical and coliform analysis of water samples from the Irisan tunnel over a ten-month period show that the water is unsuitable for human consumption. The mean values for all the parameters determined in the study were compared with those which support a "Class A" type of water supply. The results of bacteriological and residual chlorine tests strongly suggest the need for disinfection and for other types of treatment as prescribed by the NSDW of the Philippines for "Class A" waters.

A random survey of 52 households (approximately 12% of the total number of households) in Barangay Irisan shows that the economic gains from the dumpsite are mainly due to scavenging and recycling opportunities. The survey results further indicate that the major issues of concern of the residents are centered not on the environmental conditions that prevail in the area and the effects of these on the health of the residents but more on economic needs.



## **A COMMUNICATION STRATEGY TO STRENGTHEN AGRICULTURAL COOPERATIVES IN SOUTHERN PALAWAN**

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The authors sought to prepare a communication strategy plan for agricultural cooperatives in four municipalities and one city in the southern province of Palawan, namely: Aborlan, Narra, Quezon, Brooke's Point, and the city of Puerto Princesa. The socio-economic and demographic characteristics, the communication-related characteristics, and psychological characteristics of the respondents were studied to find out if these were related to the present knowledge, attitudes, and practices of the respondents regarding cooperatives. The suggestions of the respondents on how to improve the cooperative program were also looked into in this study.

Three hundred respondents were surveyed using a pretested questionnaire from December 1994 to May 1995. The responses were coded and analyzed using frequency counts, means, and percentages. Knowledge and practice were measured using a Likert scale of 3 to 1 with 3 labeled as "fully practiced"; 2, "slightly practiced"; and 1, "not practiced". On the other hand, attitude was measured using the same scale of 3 to 1 with 3 labeled as "strongly agree"; 2, "neutral"; and 1, "strongly disagree". The Chi-Square Test of significance at 10 percent level was used to determine relationship among variables.

Results revealed that the average age of the respondents was 40 years, majority were male, married, had some formal education, and had an average monthly income of P2,320.

Radio, magazines, newspapers, television, and comics were the most available mass media communication channels. The respondents had very limited sources of cooperative information, hence they felt a great need for information on cooperative management, bookkeeping and accounting, values education, and cooperative profit-sharing. They considered radio, interpersonal sources, television, and comics as credible sources of information. However, they preferred radio, interpersonal sources, and pamphlets as sources of information on cooperatives. The respondents further expressed a need for re-education on the concepts and operations of cooperatives, and majority believed that the cooperatives program would be successful.

The respondents generally have relatively high knowledge and practice levels on cooperatives and favorable attitudes.

Findings also revealed that there was no relationship, between the respondents' socio-economic and demographic characteristics, communication-related characteristics, and their present knowledge, attitude, and practice regarding

cooperatives. However, perception of the success of the cooperatives program was significantly related to knowledge, attitude, practice.

Based on the findings, a communication strategy which is audience-oriented, need-oriented, and resource-oriented was formulated. It is hoped that this strategy will strengthen the agricultural cooperatives in Southern Palawan.

## **THE LUMADS OF MINDANAO: BELIEF SYSTEM AND FOLKLORE\***

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This is a study of the extent of folklore awareness and knowledge of ethnic tribes around Mt. Apo National Park. It describes the influence of cultural integration of the natives with mainstream ethnolinguistic groups and vice versa with regards to their belief systems and folklore.

Qualitative and quantitative methods of investigation were used. To confirm the folkloricity of some data, a vertical test and/or a horizontal spread test were/ was applied.

Results showed marked awareness of indigenous myths on creation among the Matigsalog, the B'laan, the Ata, the Manobo, the Ubo, and the Tagabawa tribes. This was observed among the Guiangan, the Tagaculo, and the T'boli to a slight extent.

A similar trend is noted with regards to awareness of other folklore: legends, folktales, fables, folksongs, riddles, and proverbs.

Knowledge of indigenous folklore had deteriorated in all study tribes, with less than half (41.8%) of respondents admitting knowledge about it and only 37% of them admitting that there are tribal people who can still narrate indigenous legends. Folklore gathered and documented reflected the people's close association with nature such as land, mountains, rivers, lakes, and animals in the forest. Briefly, there is marked acculturation among these tribes but traditional consciousness in the form of animistic beliefs and practices have not been completely smothered.

\*Best poster paper award in the Social Sciences Division.



**POSTER ABSTRACTS  
PRESENTED IN BICUTAN**

***AGRICULTURAL SCIENCES DIVISION***

**STUDY ON THE DURIAN FRUIT BORER AND  
ITS CONTROL**

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A study was conducted from 1990 to 1994 to determine the life cycle, alternate hosts, and control of the durian fruit borer (*Conogethes punctiferalis* Guen.). Results revealed that the durian fruit borer completes its cycle in 39 days with a larval period of 22-25 days which undergoes five instars, 7.25 days pupal, and 9.5 days for longevity of the adult. All larval stages are destructive but the fourth and fifth are the most. These larvae feed on young and mature fruits.

Identified alternate hosts are rambutan, guava, chico fruits, and cacao pods. Durian fruit borer can survive in these hosts in the absence of durian fruits. On the other hand, chemical control using Cypermethrin (0.00125 a.i./ha.); Lamdacyhalothrin (0.00625 a.i./ha.); Deltamethrin (0.00625 a.i./ha.), or Carbaryl (0.480 a.i./ha.); and physical exclusion by bagging significantly lowered the infestation from 10.33% to 3.33% compared to the untreated with 47.40%, and increased yield from 310,000.00 to 400,000.00/ha. The highest net benefit was obtained from spraying Deltamethrin prior to bagging with 378,807.00. However, spraying of Lamdacyhalothrin 3 weeks after fruit setting (3WAFS) gave the highest MMR of 3.49-5.90%.

## ***Agrobacterium tumefaciens* MEDIATED TRANSFORMATION OF JAPONICA AND INDICA VARIETIES OF RICE\***

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Genetic transformation of rice (*Oryza sativa* L.) mediated by *A. tumefaciens* has been confirmed for japonica and indica varieties. Immature embryos were inoculated with either *A. tumefaciens* At656 (pCNL 56) or LBA4404 (pTOK233). Experimental conditions were developed initially for immature embryos treated with strain At656, based upon both transient and stable *GUS* activities. However, plant regeneration following selection on G418 (pCNL56 contains the *npt* gene) did not occur. Using the same basic protocol, but inoculating immature embryos of rice within LBA4404 (pTOK233) resulted in efficient (about 27%) production of transgenic plants of the japonica variety, Radon, and an acceptable efficiency (from 1-5%) for the indica varieties IR 72 and TCS10. Transformation was based upon resistance to hygromycin (pTOK233 contains the *hpt* gene), the presence of *GUS* activity (from the *gusA* gene), Southern blots for detection of the integrated *gusA* gene, and transmission of *GUS* activity to progeny in a Mendelian 3:1 segregation ratio. Southern blots indicated two to three copies of the gene integrated in most transformants. Transgenic plants of both the japonica and indica were self-fertile and comparable in this respect to seed-grown plants.

Key factors facilitating the transformation of rice by *A. tumefaciens* appeared to be the use of embryos as the explant, the use of hygromycin as the selection agent (which does not interfere with rice generation), the presence of extra copies of certain *vir* genes on the binary sector of pTOK233, and maintaining high concentrations of acetosyringone for inducing the *vir* genes during co-cultivation of embryos with *Agrobacterium*.

This recent breakthrough in rice genetic transformation will facilitate foreign gene introgression into rice. Genes for disease and pest resistance and tolerance to extreme environmental conditions can be introduced into the T-DNA of the binary vector. Through *A. tumefaciens*-mediated transformation, these genes will be stably integrated into the nuclear genome of rice. Transformants can be selected through the use of selectable genes in the T-DNA.

\*Best poster paper award in the Agricultural Sciences Division.

## **DEVELOPMENT OF A FARM-LEVEL DRYER**

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A simply designed recirculating dryer was developed suited for farm-level operation. It was fabricated in Tacurong, Sultan Kudarat, and tested to determine its performance. Unique in its design is the bigger drying chamber with a simple grain flow mechanism. With wet paddy as test material, the prototype has a capacity of 5 metric tons with drying capacity of 91.53% and relatively low drying cost of about P9.93/cavan utilizing kerosene pot burners as source of heat. An improved commercial model is recommended.

## **ON-FARM PERFORMANCE OF FEEDLOT CATTLE FED WITH LOCAL FEEDSTUFF WITH OR WITHOUT SUPPLEMENTATION**

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This research was composed of two interrelated on-farm studies. In Study I, 20 grade Brahman feeder cattle were randomly assigned to two dietary (local feedstuff alone-LF, and LF + concentrates-CON) treatments for a 120-day feeding trial. In Study II, 21 grade Brahman feeder cattle were randomly assigned to three dietary (LF + CON, LF + Urea mineral molasses block UMMB, and LF + CON + UMMB) treatments using a Completely Randomized Design (CRD) with seven replications per treatment. The feeding trial also lasted for 120 days. Both studies measured performance of the animals in terms of voluntary intakes, weight gain, feed efficiency, cost per kilogram gain in weight, and economic returns.

Results of Study I showed comparable dry matter intakes of cattle fed with LF alone and LF + CON despite the concentrates constituting only 17% of the diet of the treated group. Daily gain in weight, however, was significantly higher in the concentrate-fed group (635 g vs 244.2 g for the group fed LF alone). Likewise, feed efficiency of the concentrate-fed group (15.1 kg) was significantly better than those

given LF alone (43.1 kg). Concentrate feeding, therefore, required lesser cost of feed to produce a kilogram gain in weight (P24.05 vs P43.15 for those receiving LF alone). The return above variable cost was P1,641.00 per head for the former and P156.70 for the latter. No significant difference was observed on the dry matter intakes of animals in Study II. On the other hand, while the average daily gains (ADGs) of animals supplemented with concentrate alone or with UMMB were comparable, both ADGs were significantly higher than those fed with LF plus UMMB alone. Moreover, feed efficiency of groups fed with concentrates alone or with UMMB was significantly better than those fed with UMMB alone. It was cheapest to produce liveweight gains with CON plus UMMB. Furthermore, greater returns above variable costs were derived with CON plus UMMB.

### **POND HATCHERY CYCLE TECHNIQUE OF MASS SEED PRODUCTION OF *Oreochromis niloticus* L.**

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The results showed that the hatchery cycle of 30 days as an innovative technique for the optimization of synchronized spawning among the Nile tilapia female breeders was significantly more efficient for mass seed production in a pond than that of the 60-day hatchery cycle. The *Oreochromis niloticus* in a 30-day hatchery cycle produced seed of 4.43 compared to 0.85 per spawner per day at a 60-day hatchery cycle. In terms of daily seed production per square meter, the former technique showed higher harvest of 8.87 in comparison to that of the latter's 1.69. Though seed harvest trials were insignificantly different from each other, the seed production consistently increased from the first to the third harvest.

### **TOMATO POMACE - A NEW LIVESTOCK FEED IN THE ILOCOS**

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Throughout the Asian region, the cost and availability of feed are probably the most important constraints in livestock production. Consequently, there is a

growing search and use of locally produced feed resources. These include treated rice straw and other crop residues, silage made from pasture grasses grown as part of a complex cropping system, and waste products from agroindustry.

These not only involve the search for new sources but also for ways in which the supply may be extended to cover a longer period. In Ilocos Norte, tomato production has become a major agricultural venture and is being processed in the area as tomato paste. Tomato pomace is a by-product in this process, which is about 70% of the total weight of the tomato processed, and as such it is becoming an environmental threat.

In an exploratory feeding trial with growing-fattening cattle, tomato pomace was found to be highly acceptable up to as high as 70% of the roughage ration and to result in higher liveweight gain. Due to the perishability of the material, ensiling it with dried corn stover and feeding it after at least 2 weeks of treatment, was also found to be highly acceptable, and to result in better liveweight gain.

With these initial results, tomato pomace is a potential feed for livestock in Ilocos Norte and in places where this material is available

## **ZINC SULFATE TURBIDITY TEST AS A MEASURE OF SERUM IMMUNOGLOBULIN STATUS IN NEONATAL PIGS**

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A total of 56 presuckled large White Landrace cross piglets from 8 litters of varying parities (parities 3, 4, 6, and 8) were used in this study. Sows were monitored while farrowing to make sure the piglets did not suckle before the initial sampling. Piglets were bled twice at zero hour (presuckle) and 24 hours after birth (postsuckle) by vena cava puncture.

This study was conducted to evaluate the Zinc Sulfate Turbidity Test (ZST) as a method of determining immunoglobulin concentrations in neonatal pigs. The data were analyzed using SAS/STAT computer programs.

It was found in this study that parity and litter are factors influencing variation in immunoglobulin concentration in piglets at zero hour after birth. This method also can differentiate between piglets that have high or low concentrations of total serum immunoglobulins.

The ZST is a quick, inexpensive test and has a practical application in assessing the level of transfer of immunoglobulins in piglets during the first 24



hours after birth, thus providing a means of determining the colostrum uptake and utilization. Such information could be used by the animal technician to investigate the common problems of milk let-down failure and neonatal diseases which are commonly seen in pig production

**COMPARATIVE ULTRASTRUCTURES OF VITREOUS AND  
NON-VITREOUS IN VITRO GROWN SWEET POTATO  
[*Ipomoea batatas* (L.) LAM.] PLANTS**

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Vitrification, a physiological disorder characteristic of in vitro grown plants, was observed in single node cultures of sweet potato in mannitol-enriched medium during their second year of storage. Vitrified or vitreous sweet potato plantlets were watersoaked, translucent or glassy in appearance, with thick, swollen leaves and stems, stunted shoot growth, and poor root growth. These plantlets were not able to regenerate normal plants when transferred into fresh medium nor were they able to survive outside culture conditions.

Electron microscopy revealed changes in the ultrastructures of vitrified sweet potato plantlets. Vitrified plants had defective stomatal complexes, starch grain-filled chloroplasts, disrupted cell walls, big air spaces (lacunae), high frequency of cell membrane separation from the cell wall, nuclear disintegration, and cytoplasmic disorganization. These changes in the internal structures of vitrified plants were reflected in their abnormal morphology and physiology.

## **RATE AND LEVEL OF EFFECTIVITY OF TUBA (*Croton tiglium* L.) FOR THE CONTROL OF WEEVIL ON STORED GRAINS OF CORN AND MUNGBEAN**

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The weevil, a storage pest of corn and mungbean, is the most serious problem of farmers nationwide causing inadequate supply of quality seeds for the succeeding cropping season. Seed treatment by chemical means has become widespread but this needs care because of risk to farmers and consumers due to chemical residues.

Tuba (*Croton tiglium* L.) seeds were identified as the most effective botanical material against weevil in stored grains of corn and mungbean. A study on the rate and level of effectivity of tuba seeds against weevil on stored grains of corn and mungbean was conducted in 1993. Results revealed that powdered tuba seeds at the rates of 10, 15, 20, and 25 g/kg (corn/mungo) seeds can be used as seed treatment against weevil in stored grains of corn and mungo and can preserve viability up to 30-90 days. Results also revealed that the higher the amount of tuba seeds, the higher is the level of effectivity, thus lowering the percentage damage and resulting in higher viability and germination percentage of the seeds. Powdered tuba seeds protect stored corn and mungbean from weevil infestation.

## **PROMISING POTATO CLONES FOR THE LOWLANDS**

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Potato can be cultivated in several thousand hectares in the lowlands of the Ilocos Region during the cool dry season months. Cultivation of the crop in the past, however, was dependent on the quality of seed tubers produced in the highlands. Lowland farmers tried to produce seeds stored under diffused light at ambient temperature for eight months after harvest in rustic facilities because of lack of appropriate seed cold storage. However, the currently recommended potato varieties for the lowlands are not suited to this type of storage.

As a part of a strategy to provide alternative sources of seed tubers, new lowland potato clones were evaluated and developed at the Mariano Marcos State University in collaboration with the International Potato Center (CIP). The evaluation process was done on-station and on-farm from 1991 to 1995. Farmers, researchers from MSU and CIP, agricultural technologists of the Department of Agriculture, and other government officials participated in the selection of the clones.

The most promising clones were CIP 385130.5, CIP 385130.6, CIP 385130.11, CIP 385130.77, and CIP 385383.1. These clones mature in 75 to 85 days and produce 19.9-21.1 t/ha medium to large size tubers. The tubers have good eating quality and can be processed into chips, particularly those of CIP 385130.5 and CIP 385130.11. These clones produce higher yields than the varieties recommended for the lowlands such as Cosima, Berolina, and Kenebee. The seeds can be stored in diffused light storage chambers for eight months following the rustic storage practices of farmers.

Collectively, these promising potato clones can sustain the seed requirements of the lowlands. There is now a bright hope for the commercialization of the potato technology in the lowlands.

## **DETERMINATION OF DAIRY COW BODY CONDITION SCORES**

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In recent years, a large number of Holstein x Sahiwal crossbred dairy cows have been introduced in Mindanao, particularly Davao, as part of the dairy development efforts to set up nucleus dairy cooperatives and a viable dairy industry. In such dairy production systems, a rigid selection and culling scheme is an effective management tool for herd improvement and this skill is a must for a dairy farmer. The score card of body condition is a reference to enable accurate and objective judgment of the physical attributes of the animal.

This paper presents body condition scores for locally born Holstein-Friesian and crossbred Holstein x Sahiwal cows that could be utilized by local dairy farmers. Body condition scoring is necessary to know the health status of an individual cow or the whole herd, the appropriate feeding level in relation to the present production, and to plan future feeding strategies and management systems. The ultimate goal is to achieve optimal body condition for significantly improved cow production and health.

## **UTILIZATION AND FORMULATION OF SULFUR AND CALCIUM OXIDE/QUICKLIME (SQL) AS FOLIAR FERTILIZER: ITS EFFECT IN THE GROWTH, YIELD, AND SEASONALITY OF MANGOSTEEN**

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Three periods of heavy vegetative flushings were observed in SQL treated trees for five months while only one period of flushing and relatively few flushes were observed in untreated trees. Results indicated a significant increase in the number and weight of fruits from the SQL treated trees. A mean yield of 2,007 kg/ha was obtained from trees treated with 1:35 SQL concentration during the 1st harvest (September 1994) while untreated trees yielded 646.12 kg/ha. From the second crop (March 1995) the highest yield (2,420 kg/ha) was obtained from trees treated with 1:55 SQL concentration. In July 1995, a third crop was produced and SQL treated plants yielded an average of 756 kg/ha.

The three periods for a duration of 12 months could imply that biennial flowering in mangosteen can be manipulated through micronutrient fertilization and could offer growers tremendous production potentials in Mindanao where a wide area highly suitable for the crop exists.

## **POLLUTION POTENTIAL OF ENDOSULFAN USING MODEL ECOSYSTEMS**

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Two model rice paddy ecosystems were devised in the laboratory using 50-gal glass aquaria. In model Ecosystem I, artificial rain was applied on endosulfan treated paddy rice using the t-jet nozzle sprayer and drained into a simulated lake ecosystem. In model Ecosystem II, artificial rain was not applied.

The decline of endosulfan residues in rice plants as a result of applied rainfall in model Ecosystem I was faster with 94% reduction on the 7th day, whereas only

up to 32% in model Ecosystem II without rainfall. The residues which were washed out from the plants were deposited and added up on the soil. Endosulfan residues detected on paddy water before rainfall was 1.2 ppm which increased to 3.9 ppm after rainfall due to washing of surface residue from the leaves.

The paddy water which was drained into a simulated aquatic ecosystem resulted in low residue content down to 0.2 ppb at zero to 14th day of sampling. However, this was still toxic to fish causing high mortality. The fish were able to bioconcentrate the residues 5 to 214 times the concentration of endosulfan in water. This is one of the greatest problems in pesticide pollution.

## **RAPID BIOASSAY OF PESTICIDE RESIDUES IN VEGETABLES**

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A rapid bioassay for pesticide residues (RBPR) was used in screening organophosphate and carbamate insecticides in vegetables within Laguna area. The rapid bioassay is based on the inhibition of enzyme by organophosphate or carbamate insecticides using purified housefly acetylcholinesterase. This enzyme is responsible for hydrolyzing acetylcholine, a chemical transmitter of stimuli from one nerve cell to another.

In general, slightly lower sensitivities were obtained for the crude AChE than the purified enzyme. The activity of the crude AChE compared well with TARI's purified acetylcholinesterase with activity of  $1.09 \times 10^{-2}$  mol/min/mL and  $1.02 \times 10^{-2}$  mol/min/mL, respectively. These results indicate that freshly prepared crude AChE may be used in screening pesticide contamination in vegetables using the rapid bioassay method.

Of the 165 vegetables samples assayed, 11/3% gave more than 20% inhibition of acetylcholinesterase, a confirmation of the presence of insecticide residues, the higher the degree of enzyme inhibition the higher are the residues of insecticides. Gas chromatographic analysis revealed that samples which exhibited an inhibition of 348% exceed the Maximum Residue Limit (MRL) set by FAO/WHO for methomyl, triazophos, and diazinon. Samples which exhibited 20-40% inhibition have residues of methyl parathion, chlorpyrites, and malathion at levels within the MRL set by FAO/WHO.

## ***BIOLOGICAL SCIENCES DIVISION***

### **TERATOGENICITY OF ORGANOPHOSPHATE PESTICIDE ON *Tilapia nilotica***

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Since the ban on organochlorines, organophosphates have been extensively used in agriculture as pesticides in order to increase crop production. However, their indiscriminate use has resulted in the presence of their residues in rivers and lakes. This study evaluates the effect of commercial grade malathion [S-(1, 2-dicarbethoxyethyl)-O,O-dimethyldithiophosphate] EC 57 on *Tilapia nilotica* embryos. Results of this study would provide (1) baseline data on pesticide effects on nonpests, particularly on fishes, and (2) information for government agencies that will guide them in the formulation of policies on pesticide use.

Day-10 post hatching embryos that were exposed for 60 days to sublethal doses of 0.3 mg/L malathion exhibited various aberrations. Brain defects included nuclear blebs, swollen short-stranded endoplast, and degranulated endoplasmic reticulum. The cytoplasm exhibited an electron-light background and extensive vacuolations. The gonads of pesticide-treated embryos showed delay in ovarian differentiation and cavitation in older embryos. The notochord lost its secondary sheath and was significantly larger than that in the control. The gills showed epithelial lifting and mucus secretions.

**HEMATOLOGICAL RESPONSE OF TILAPIA  
(*Oreochromis niloticus*) TO ZINC  
AND MERCURY EXPOSURE**

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Tilapia fingerlings of 4-5 cm total length were exposed to 0, 2, 5, and 10 ppm zinc sulfate for 30, 60, and 90 days while adult fish of 15-20 cm total length were exposed to 0.05 mg/L mercuric acetate for 7 days. Anisocytosis and poikilocytosis which are frequently observed in most anemias were noted in blood smears of zinc-treated fish. Hemoglobin level was reduced in fish reared at 10 ppm for 90 days while hematocrit was increased in fish reared at 2, 5, and 10 ppm in all treatment periods. An increase in hematocrit was correlated with fish response to hypoxemia to compensate the oxygen-carrying capacity of the circulating blood. Anemia is attributed to reduced hemoglobin content of erythrocytes. In mercury-treated fish, hemoglobin, RBC count, hematocrit, mean corpuscular hemoglobin, mean corpuscular volume, and mean corpuscular hemoglobin content decreased significantly while a significant increase in number of immature erythrocytes was observed. Abnormalities in erythrocyte morphology such as heart-shaped cells, triangular cells, and irregularly contracted cells were noted. Atomic absorption spectrophotometry revealed elevated mercury levels in the head and kidney.

**THE ECOLOGY OF THE MIGRATORY LOCUSTS,  
*Locusta migratoria manilensis* MEYEN**

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The migratory locust is an endemic pest of the Philippines. Infestations have been recorded as early as the 1500s by Augustinian friars. However, until now there is a dearth of information as far as the ecology of this pest in the Philippines is concerned.

Recent findings regarding flora and fauna associated with locusts in breeding areas; updated morphometrics of solitary and gregarious phases; new behavioral

observations; correlates of soil properties and egg-laying; and recent factors about migration of locusts in Central Luzon and other parts of Luzon are discussed.

## INCIDENCE OF GILL AND INTESTINAL PARASITES FROM THREE SPECIES OF SCOMBRID FISHES

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Eleven species of parasites belonging to different genera were recovered from the gills and intestinal tracts of three species of scombrid fishes obtained from a local wet market. The parasites were 2 Digenea, 5 Monogenea, 2 Copepoda, 2 Nematoda, and 1 Acanthocephala. The digenetic trematode, *Lecithocladium* sp. Luhe, 1901 was the most prevalent parasite recovered from *Rastrelliger brachysomus* (Bleeker) (100%) and *R. chrysozonus* (Rupell) (96.7%). In *Scomberomorus commerson* (Lacepede), the highest incidence of infection was due to the gill fluke, *Scomberocotyle* sp. (100%). Mean intensity of the infection in *Rastrelliger* spp. was the highest for the same parasite (*Lecithocladium* sp.); in *S. commerson*, the highest mean intensity of infection was shown by the nematode *Spinitectus* sp. Fourment, 1883.

## MOLECULAR CHARACTERIZATION OF *Bacillus thuringiensis* ISOLATES HIGHLY TOXIC TO YELLOW STEM BORER

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*Bacillus thuringiensis* (*Bt*) is a rod-shaped, Gram-positive bacterium that produces insecticidal crystal proteins during sporulation. The toxin proteins CryI<sub>Ac</sub>, CryII<sub>C</sub>, and CryII<sub>A</sub> have been found to be most effective against the rice yellow stem borer (YSB), *Scirpophaga incertulas*. Close to a thousand representative *Bt* isolates from the collection of the International Rice Research Institute (IRRI) have been bioassayed for toxicity to YSB. Eighteen *Bt* isolates that showed consistently high



toxicity, comparable to the standard *Bt* strain, *Bt* strain HD-73 which produces only CryI<sub>Ac</sub> in repeated bioassays, were chosen for more detailed evaluation. A series of PCR primers specific to ten different *cry* genes were used to determine the group/subgroup of the toxin present in each isolate. Three *Bt* isolates harbored only one *cry* gene each while the other fifteen contained at least three *cry* genes. Immunological analysis using an antibody to the CryIIA toxin indicated that the *cryIIA* gene may be "silent" in some isolates. From the combined PCR and immunological analyses, *Bt* isolates 182, 222, 271, and 734 stand out as particularly interesting. They are of high toxicity to YSB yet do not have *cryI<sub>Ac</sub>*, *cryII<sub>C</sub>*, or *cryIIA*. It is possible that these four isolates contain novel *cry* genes of potential use in rice and our initial cloning efforts will be focused on them.

## DNA FINGERPRINTING OF THE BACTERIAL BLIGHT PATHOGEN OF RICE USING PCR-BASED METHODS

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Repetitive DNA sequences are pervasive in the genomes of most organisms. Their conserved nature and variable distribution in the genome allows the detection of many polymorphisms that are useful in differentiating individual strains. IS112 is a high-copy number of repetitive elements isolated from the bacterial blight pathogen. A primer pair complementary to IS112 was used to fingerprint a set of 71 *x oryzae* pv. *oryzae* strains using PCR and ligation-mediated PCR (LMPCR). To allow amplification of long DNA fragments, we amended standard amplification conditions by increasing the pH, adding dimethylsulfoxide, decreasing denaturation time, and increasing extension time. Both PCR and LMPCR revealed useful polymorphism among individual strains and allowed their genetic relationships to be efficiently deduced. Good correlation was found between the major clusters obtained by the two methods. The bootstrap values, which indicate the strength of the groupings, are generally high for the major clusters produced, with PCR giving the most robust clusters. Overall, the PCR method was most efficient in terms of simplicity and economy. The PCR and LMPCR methods were used to characterize field isolates of the bacterial blight pathogen. Similar groupings of the isolates were obtained. Further, these groupings corresponded well to those derived using restriction fragment length polymorphism.

## **LITTORAL BENTHIC FAUNA OF LAKE TAAL, BATANGAS**

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Core samples were collected from six stations in the shore areas of Lake Taal from August 1994 to January, 1996. The animals recovered from the samples and their average densities per liter of sample were: gastropod molluscs (39.1), pelecypod molluscs (4.1), annelids (8.9), crustaceans (18.3), and insect larvae (1.7). The predominant species of gastropods, annelids, and crustaceans found were *Thiara granifera*, *Dero* sp., and *Sphaeroma* sp., respectively. The pelecypods belonged to one species, *Corbicula manilensis*. The insect larvae were chironomids. Variations were observed in the spatial and temporal distribution of the benthic animals. Higher densities were observed in sampling sites with moderate to abundant aquatic vegetation and during the months of April to July.

## **THE DIVERSITY AND ABUNDANCE OF THE ZOOPLANKTON IN LA MESA DAM, METRO MANILA**

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The zooplankton community of La Mesa Dam, the storage reservoir for pre-treated drinking water in Metro Manila, exhibits (i) remarkable species diversity in spite of its small volume and surface area and (ii) little or no variation in the composite densities of the Cladocera and Rotifera.

Samples collected in the littoral and limnetic zones of La Mesa Dam beginning in 1975 yielded 32 species of Rotifera, 22 spp. of Cladocera, and 8 spp. of Copepoda. In 1990-1991, the numbers of Cladocera and Rotifera varied very little in spite of the seasonal variations in the level of the water of the dam. Plankton densities showed no correlation with some water quality parameters that were monitored.

**THE DEVELOPMENTAL BIOLOGY OF THE  
ANGEL WING CLAM (*Pholas orientalis*), AN ENDANGERED  
SPECIES OF MOLLUSK NATIVE TO PANAY AND  
NEGROS ISLANDS\***

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The angel wing clam (*Pholas orientalis*), or more popularly known as “diwal” in the Hiligaynon dialect, is a large mud-burrowing bivalve native to the tidal mud flats of Panay and Negros islands. The name “diwal” is derived from the habit of the clam in extending its long siphon out of the mud when feeding on minute plankton in the seawater column. Because of its large size, juiciness, and sweet taste, “diwal” has been one of the most expensive and most sought after edible bivalves in the Philippines. Unfortunately, such exceptional characteristics make it not only a local delicacy but also a much sought after export commodity.

Diwal was most abundant in Roxas City (notably in Barangay Bara) in the Capiz Province of Panay, and in the municipalities of Pontevedra and Hinigiran in Negros Occidental. However, there has been a dramatic decline in the population of diwal in both islands beginning in 1990. Once the pride of Roxas City, the sea food capital of the Philippines, diwal is now nearly extinct in Barangay Bara and rarely found elsewhere. The reason for this phenomenon remains unknown. The most likely causes are the same which caused destruction of most other marine life forms, namely over-harvesting, pollution, siltation, and destruction of the ecosystem. Understanding the biological conditions which affect the life cycle of diwal is difficult because there have been no published scientific data on its biology and ecology.

A research program was initiated to establish the development biology of diwal as part of the long term plan of rehabilitating the coastal environment. Adult diwal were successfully spawned naturally in the laboratory. The development of the embryos and larvae was monitored using a Nikon microscope interfaced with a

\*Best poster paper award in the Biological Sciences Division.

video camera and using Global Lab Image analysis software. Newly spawned eggs measuring 42  $\mu\text{m}$  were isolecithal with modified holoblastic cleavage. From the seventh cleavage stage the embryos became motile. The trochophore and veliger stages were active swimmers. It took the zygotes about 23 hours at 29 ppt salinity, 24.5-28.0°C, and pH 8.04-8.14 to reach post-set stage. Subsequently, the larvae were fed with "Akemi" diet up to 3 months old juveniles (390  $\mu\text{m}$ ). This is the first time that *Pholas orientalis* was naturally spawned and the hatchery technique for its larval production was developed.

The present technology is significant because it will pave the way for field introduction of hatchery-produced diwal for coastal rehabilitation in the very near future.

## DETECTION OF SEQUENCE POLYMORPHISMS AMONG SELECTED CLONES OF ABACA (*Musa textilis* NEES) BY RAPD ANALYSIS

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The technique of random amplified polymorphic DNA (RAPD) was used to investigate DNA sequence variation in eight clones of abaca (*Musa textilis* Nees) obtained from existing germplasm collections. Conditions were optimized for the generation of RAPD markers for abaca. A total of 100 different random 10-mer primers from Operon Technologies were tested to reveal DNA polymorphisms among the different clones. Fifty-eight out of the 100 random primers tested yielded intense and well-resolved amplification products. Four primers (OPU-01, OPV-14, OPV-20, and OPX-04) used together enabled the discrimination of all abaca genotypes tested. However, primers OPU-01 and OPX-04 proved sufficient in discriminating genotypes collected from the Bicol region with collections from other places. This study shows that RAPD analysis can be employed to generate fingerprints of eight abaca genotypes and estimate their genetic relationships based on the analysis of polymorphisms identified.

## NOVEL ANTIMICROBIAL SUBSTANCE FROM A STRAIN OF *Vibrio* sp.

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The structure of a novel antimicrobial substance isolated from a strain of the bacterium, *Vibrio* sp. was determined to be 7,7-bis(3-indolyl)-*p*-cresol on the basis of spectroscopic data. The substance showed specific inhibition against *Bacillus subtilis* with a minimum inhibitory concentration of 69 µg/mL but did not affect the growth of the other test microorganisms.

## THE ANTIMICROBIAL ACTIVITY OF SOME MARINE SPONGES FROM KAUSWAGAN, LANAO DEL NORTE

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Sponges collected from Kauswagan, Lanao del Norte in September 1986 were investigated for their potential as sources of antimicrobials. Extracts of eleven

species of fresh and dried marine sponges belonging to eight families under Class Demospongia were tested for their activity against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis*, *Candida utilis*, and *Aspergillus niger*. The filter paper disc method of antimicrobial assay was done against solvent controls and the broad spectrum antibiotic, streptomycin. Ten of the sponge species namely *Adocia* sp., *Pellina* sp., *Cribrochalina* sp., *Xestospongia* sp., *Trachyopsis* sp., *Halichondria* sp., *Suberites* sp., *Phyllospongia* sp., *P. foliascens*, both juvenile and mature *Biemora fortis*, and *Plakortis* sp., demonstrated varying antimicrobial activity depending on the state of the material and the nature of the extract or the solvent used. Extracts from fresh sponges showed greater inhibitions of microbial growth compared with extracts from dried specimens. Ethanol showed greater efficiency in extracting active components from fresh sponge while methanol-toluene was efficient with dried sponge. Inhibition was greatest against Gram-positive bacteria: *Adocia* sp., *Pellina* sp., *Cribrochalina* sp., *Trachyopsis* sp., *Suberites* sp., and *Phyllospongia foliascens* also inhibited the fungi. *Mycale* sp., the eleventh species, did not show any antimicrobial activity.

## IDENTIFICATION OF CHROMOSOMAL REGIONS UNDERLYING SOME QUANTITATIVE TRAITS IN RICE USING RFLP, RAPD, AND AFLP MARKERS

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The development of molecular genetic maps has facilitated the identification of genes controlling quantitative characters referred to as quantitative trait loci (QTLs). A molecular map based on a tropical japonica x indica cross (Labelle/Black Gora) was constructed using restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), and amplified fragment length polymorphism (AFLP) markers. The map spanned 1476 centi Morgans (cM) with markers on all 12 rice chromosomes and an interval spacing of 11 cm. QTL analysis was performed using Mapmaker/QTL with a log-likelihood threshold of 2.5. An average of 3.3 putative QTLs were identified for two reproductive and five seed traits studied.

Four QTLs controlled the number of spikelets per panicle, filled seeds per panicle, seed length, and seed breadth. Three controlled percentage fertility and seed shape and were mapped for seed weight. Several genomic regions influenced

more than one trait. The trait variation accounted for by each QTL ranged from 6 to 27%. QTLs with large effects may be useful for marker assisted selection strategies. The multiband and high-resolution AFLPs were randomly distributed across the rice genome indicating their suitability for gene tagging and DNA fingerprinting in rice.

**FINE MAPPING OF THE GREEN LEAFHOPPER  
(GLH-*Nephotettix virescens* DISTANT)  
AND RICE TUNGRO SPHERICAL VIRUS (RTSV)  
RESISTANCE GENES IN RICE CV. ARC 11554**

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The GLH and RTSV resistance genes were mapped on chromosome 4 of ARC 11554. In this first report, several molecular markers were linked to the resistance genes. Using the non-radioactive enhanced chemiluminescent (ECL) method of molecular marker labeling and detection, a fine map was constructed around the GLH resistant gene, and several markers were found putatively flanking the RTSV (ARC 11554/7TN1) plants. This mapping population was phenotyped for both GLH and RTSV resistance using GLH antibiosis and enzyme linked immunosorbent assay (ELISA). Another F<sub>2</sub> population was also used to find flanking markers within 5 cM from the GLH resistance gene and these have been identified. Molecular markers flanking the RTSV resistance gene have also been found. We are now using the tightly linked molecular markers to design and test sequence tagged site (STS) markers.

**THE HEMOLYMPH OF *Pomacea canaliculata*  
AFTER EXPOSURE TO  
SUBLETHAL CONCENTRATIONS OF CADMIUM**

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Laboratory-reared *Pomacea canaliculata* snails were exposed for two weeks to sublethal concentrations of cadmium chloride after which the hemocyte composition of hemolymphs was studied. Both granulocytes and agranulocytes

were observed to occur. The total hemocyte count was found to increase with increasing concentration of the cadmium salt. Differential cell count showed that intermediate (0.1875 ppm) and high (0.375 ppm) sublethal concentrations of  $\text{CdCl}_2$  caused significant increases in granulocyte number. SDS-PAGE profiles of soluble hemolymph proteins from control and experimental snails showed differences in banding patterns.





## ***HEALTH SCIENCES DIVISION***

### **GROWTH HORMONE ADMINISTRATION IN CHILDREN WITH GROWTH HORMONE DEFICIENCY: A COMPARISON OF VARIOUS TREATMENT REGIMES\***

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Advances in research have made possible the production of biosynthetic human growth hormone in sufficient quantities. However, optimal treatment regimens for growth hormone deficiency have not yet been standardized. Differences in dosage, routes and timing of administration, and duration of treatment are of paramount importance. This study was undertaken primarily to determine whether growth hormone given alone continuously or intermittently over short periods of time will result in height increases and whether doses smaller than those recommended will result in comparable increases in height.

Twenty seven prepubertal patients with significant growth hormone deficiency as established by two consecutive stimulation tests using Clonidine, L-Dopa, and insulin induced-hypoglycemia were included in the study. Subjects were randomly assigned to four treatment regimens using biosynthetic human growth hormone daily six times a week via subcutaneous route. Group A received 0.07 IU/kg daily for 3 months, then discontinued for the next three months, after which treatment was resumed for another 3 months to complete 6 months of treatment. Group B received 0.07 IU/kg daily for 6 months. Group C received 0.035 IU/kg daily for 12 months. Group D received 0.07 IU/kg daily for 12 months.

At the end of the study, nineteen boys and six girls were evaluable. Mean chronologic age range from 9.86-12.74 years while mean bone age range from 5.79-7.43 years. Using analysis of covariance, there were no differences in the treatment effects between Groups A and B and between Groups C and D. Four patients

\*Best poster paper award in the Health Sciences Division.

developed hypothyroidism and one had transient edema. Eleven patients had elevated alkaline phosphatase after several months of treatment which subsequently reverted to normal.

This study demonstrates that all growth hormone deficient children respond positively to biosynthetic human growth hormone. There is no advantage in administering it intermittently. Small doses of growth hormone may result in growth increments which do not produce significant side effects.

## MICROCULTURE TETRAZOLIUM ASSAY FOR IN VITRO CYTOTOXICITY TESTING OF RING STAGES OF *Plasmodium falciparum*

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The microculture tetrazolium assay using MTT (3-(4,5-dimethylthiazol-2-yl)2,5-diphenyltetrazolium bromide) was optimized and applied to determine the IC<sub>50</sub> (50% inhibitory concentration) of chloroquine, quinine, artemisinin, hydroxynaphthoquinone, and sixteen sponge extracts compared to the tritiated hypoxanthine assay using a *Plasmodium falciparum* in vitro culture system. The MTT assay was also compared to a previously optimized method, the NBT (2, 2'-di-*p*-nitrophenyl-5,5'-diphenyl-3,3' (3,3'-dimethoxy-4,4'diphenylene)-ditetrazolium chloride) assay proposed by Makler et al. (1993). In general, the results show that the three assays generate comparative results.

Two other vital stains which have not yet been applied to *P. falciparum* were tried. These were Alamar Blue and KTT (2,3-bis(2-methoxy-4-nitro-5-sulfophenyl)-5[(phenylamino) carbonyl]-2H-tetrazolium hydroxide). Neither was able to differentiate parasitised and non-parasitised erythrocytes.

The results of this study suggest that the MTT method may be used as a screening alternate to the tritiated hypoxanthine assay. Used in parallel to screen for in vitro activity in 16 sponge extracts, both assays identified the same sponge as a source of a potential antimalarial drug.

## **THE CLITORAL INDEX: A DETERMINATION OF CLITORAL SIZE IN FULL TERM INFANTS**

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Although examination of genitalia is an important part of newborn evaluation, few data are available regarding normal newborn clitoral length and width. Therefore, clitoral measurements were taken in three hundred sixty four full term female infants with a mean maternal age of  $26.025 \pm 0.3$  ( $\pm$ SEM), mean birthweight 2952 grams  $\pm$ 16.42 (range 2500-3600), and mean birthlength 48.036 cm  $\pm$ 0.11 (range 45-50 cm). Two hundred eighty five infants (78.30%) were born by vertex vaginal delivery and 79 (21.70%) by caesarian section. No pregnancies were complicated by drug use or maternal illness. Using a plastic ruler calibrated in millimeters, the clitoral length and width were measured twice by a single examiner and a third measurement by the use of calipers, to produce intraobserver reliability and reproductibility. Twenty percent of the total population were again measured by a second examiner for interobserver reliability. The lower limit of measurement was 3 mm. The mean clitoral length measured  $5.049 \pm 0.046$  mm ( $\pm$ SEM) and width measured  $3.077 \pm$ SEM). The clitoral index among full term infants is  $15.84 \pm 0.457$  mm. Therefore, clitoral index measurement is a simple, easy, and economical method and must be part of a general physical examination.

## **ANOGENITAL RATIO: A CLINICAL ASSESSMENT TOOL FOR THE DIAGNOSIS OF VIRILIZATION IN FULL TERM INFANTS**

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Deviations in normal anatomy, pattern of growth, and abnormal sexual development are frequent reasons for suspecting endocrine disorders in pediatric patients. The clinical recognition of virilized genitalia manifested as labioscrotal fusion and clitoral hypertrophy warrants further evaluation since clitoral size is fully

developed by the twenty-seventh week of gestation. Androgen induced labioscrotal fusion results in an increase in anogenital distance.

It is therefore the purpose of this paper to provide normative data among full term neonates. Three hundred sixty four full term infants of 37-42 weeks gestational age were included in the study. No pregnancies were complicated by drug use or maternal illness. Anogenital distance determined were (1) Anus to fourchette (AF)-lower segment, (2) Anus to the base of clitoris (AC), and (3) Fourchette to the base of clitoris (FC)-upper segment. Using a caliper, the distances were measured in millimeters, twice by a single examiner. Twenty percent of the total population were measured by another author for interobserver reliability. The lower limit of measurement was 23 mm. The mean AF measured 24.59 mm  $\pm$ 0.002 while mean AC measured 51.33 mm  $\pm$ 0.0197, and mean FC measured 24 mm  $\pm$ 0.002. From these measurements, the FC/AC and AF/AC ratios were calculated to establish the relative length of each component distance. The ratio is 0.49-0.50 in the normal full term infants. AF is one-half of the total distance from anus to clitoris. If the ratio is greater than 0.50, it exceeds the 95% confidence limit for normal values and requires further endocrine evaluation.

## ANTI-TB ACTIVITY OF SOME PHILIPPINE SPONGES USING DIFFERENT SCREENING ASSAYS

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Tuberculosis, magnified by the increasing incidence of TB with HIV infection and the emergency of multi-drug resistant strains, continues to be the world's leading cause of death from one infectious agent. The Philippines' diverse marine resources are a potential source of anti-TB compounds that can be screened by rapid, sensitive, and inexpensive anti-mycobacterial assays.

In this study, crude MeOH extracts of 53 Philippine sponges were assayed for anti-tuberculosis activity using BACTEC, agar dilution, disk diffusion, and Alamar Blue assays. In the BACTEC assay, three extracts were found to be active against the virulent strain of *Mycobacterium tuberculosis* (H37Rv) with a minimum inhibitory concentration (MIC) range of <15.62-3.25  $\mu$ g/mL, and two were active against *M.*

*avium* (% inhibition 74.99 at 40 µg/mL). In the agar dilution assay, 11 extracts were active against H37Ra, an avirulent strain of *M. tuberculosis* with a MIC range of <15.62-250 µg/mL. In addition, tests using faster growing organisms such as *M. flavescens* and BCG yielded zones of inhibition measuring 5-15 mm. The results of the Alamar Blue assay of samples that demonstrated activity against H37Ra in the agar dilution assay indicated MICs that deviated  $\pm 1$  dilution from those obtained from the agar dilution assay.

The results of these assays suggest that of H37Ra can be used as an alternative inoculum whose sensitivity is comparable to that of H37Rv. Also, Alamar Blue assay, being less expensive than BACTEC and more rapid and sensitive than both agar dilution and disk diffusion assays, can be used as a reliable primary screening assay for anti-tuberculosis activity.



***MATHEMATICAL, PHYSICAL, AND  
ENGINEERING SCIENCES DIVISION***

**TOWARDS A CLASSIFICATION OF SPIN MODELS  
VIA ASSOCIATION SCHEMES**

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In a 1989 seminar paper, Vaughan F.R. Jones introduced the concept of spin models in statistical mechanics as a method to construct invariants of knots and links in 3-space. The spin models he designed can be defined as pairs of square complex matrices satisfying certain invariance equations, which then guarantee that the partition function defines a link invariant. In particular, he posed the challenge of investigating combinatorial structures for sources of spin models.

In 1992, Francois Jaeger found new spin models for the evaluation of the Kauffman link polynomial invariant using special association schemes which are the main objects of study in algebraic combinatorics. Subsequent work and generalizations have confirmed that the problem of constructing spin models is intimately connected with the theory of association schemes. The goal of current research is then to obtain a complete classification of spin models in terms of association schemes.

In a previous paper, we gave direct proof of the characterization of spin models arising from symmetric conference graphs. In this paper, we give proof of the characterization of (generalized) spin models arising from a non-symmetric case. We also outline the methods and direction of the classification program and discuss the latest results.



## A MEASUREMENT OF STRESS RELAXATION FOR STUDYING ROOT RESPONSE TO SALINITY

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A bending technique was used to determine the stress relaxation rate of excised rice nodal roots in bathing solutions with high concentrations of different ions and osmotica. The force produced by the root bending decreased with time indicating that the root experienced stress relaxation. The relaxation rate ( $b$ ) increased as the NaCl concentration increased. There was a highly significant relationship between the  $b$  and the water potential of the roots after bending which indicates that the  $b$  values mainly represent the response of roots to osmotic shocks. At 150 mM NaCl, 20 rice varieties showed different  $b$  values that represent the varietal difference in response to osmotic shock and root reaction to salinity. The  $b$  values after pretreatment with 50 mM NaCl for 5 d decreased for all 13 varieties tested. This result implies the adaptation and probably osmotic adjustment of roots to low water potential and the sensitivity of the bending method to detect these changes. At isoosmotic concentrations of different ions and osmotica in the bathing solution,  $b$  values were different. The preceding result implies the specificity of the effect of each ion and osmoticum on the roots. Results indicate that stress relaxation as derived using this bending method may be useful in the study of osmotic shocks during salinity treatment and the root response to different ions and osmotica. The variation in  $b$  values using different salts with the same water potential implies that this method may also show differences in root permeability to different ions and chemically related processes. The use of this bending technique, considering its simplicity in screening for salt tolerance, is considered valuable.

## SYNEPHRINE: AN ADRENERGIC DRUG FROM CALAMANSI WASTES

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Synephrine, [*p*-hydroxy- $\alpha$ -(methylaminomethyl) benzyl alcohol], was isolated from calamansi (*Citrus microcarpa* Bunge) wastes during the method of Stewart and Kinoshita. Purification was done by preparative TLC. Identification and characterization was done by chromatography, optical rotation, melting point, UV-VIS and IR absorption curves, and NMR and MS analyses.

The results recorded a yield of 0.015% (Stewart) and 0.023% (Kinoshita). Evaluation of structural elucidation results revealed that both samples are levorotatory. Synephrine (Stewart) exhibited a similar structure (C<sub>9</sub>H<sub>13</sub>NO<sub>2</sub> a secondary amine) with the standard. Synephrine (Kinoshita) suggested a protonated amine structure.

Quantitative determination of synephrine by ion-pair high performance liquid chromatography with sodium dodecyl sulfate as ion-pair reagent, showed the peel has the highest content of 0.22%, followed by the pulp (0.18%) and seed (0.02%). The leaf contained 0.12% of synephrine.

Preliminary biological studies revealed that synephrine can inhibit the contraction of rat uterus previously injected with acetylcholine.

Toxicity test (LD<sub>50</sub>) in mice of the aqueous extract showed a median lethal dose (LD<sub>50</sub>) of 23.8716 $\pm$ 0.88 g/kg.

## **THERMOCHROMIC MIXTURES CONTAINING COCO-FATTY ACID ESTERS OF CHOLESTEROL**

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Selective reflection properties of short pitch length cholesteric liquid crystals find applications in thermometry, thermal mapping, radiation sensing, and decorative and novelty products. As in the case of electro-optic applications of liquid crystals, materials intended for practical use in thermochromic devices are invariably mixtures of several different compounds. Standard formulations are commercially available from which mixtures suitable for common device applications can be derived. These commercial formulations are however costly due to expensive synthetic methods. The study presented provides an alternative route to bring down cost of production by utilizing inexpensive and readily available coconut oil and cholesterol as starting materials.

Coconut oil is a rich source of fatty acids. Esterification with cholesterol yields a mixture of coco-fatty acid cholesterol esters. The resulting mixtures show liquid crystallinity at a temperature range of 54-78 degrees Celsius. The textures observed under the polarizing microscope are typically cholesteric and smectic. Properties of several formulations based on the prepared esters are presented.

## **ANTIMICROBIAL ACTIVITY AND HCT 117 TOXICITY OF SOME PHILIPPINE SPONGES AND TUNICATES**

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A number of Philippine sponges and tunicates were extracted and assayed for antimicrobial activity. Crude extracts were tested using the standard antimicrobial streak method and these showed a wide range of inhibition against Gram-negative *Salmonella typhimurium*, *Shigella sonnei*, *Pseudomonas aeruginosa*, *Escherichia coli*, and Gram-positive *Bacillus subtilis*, *Streptococcus pyogenes*, *Micrococcus luteus*, *Staphylococcus aureus*, and the fungus *Candida albicans*. Semipure compounds isolated from a Philippine *Dictyocentrida* sp. sponge showed activity against Gram-positive and Gram-negative bacteria at less than 50 µg per disk. The same group of compounds were tested in human colon tumor cells (HCT 117) and showed toxicity at the µg level.

## ON A FAMILY OF POWER ASSOCIATIVE PSEUDOGROUPS OF ORDER $n=3m-2^*$

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The existence of an interest family of abelian pseudogroups of order  $n = 3m-2$ , where  $m \geq 4$ , has been established using a new software called FINITAS developed at the PUP SciTech R&D Center. This family has members with both lagrangian and non-lagrangian subsystems. It includes a subfamily order  $n=3(2^k) -2$ ,  $k \geq 2$ , whose members have the *alternative property*: hence they are also *disassociative* and *IP* (have the *inverse property*). Any member of this subfamily has subsystems all of which are Klein groups of order  $2^k$ . Its first four members are of order  $n=10, 22, 46$ , and  $94$ . Using FINITAS, for instance, the order  $n=46$  member has been found to have 424 proper subsystems. The analysis took less than 5 minutes to determine, from  $2^{46}$  possible subsets, these 424 subsystems!

## STRUCTURE ELUCIDATION BY NMR SPECTROSCOPY OF DNA TOPOISOMERASE II-INHIBITORY ADOCIA- AND XESTO-QUINONES FROM A PHILIPPINE MARINE SPONGE *Xestopongia* sp.

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A bioassay-guided strategy was undertaken in the isolation of a group of known and novel compounds from a Philippine *Xestospongia* sp. sponge. These

\*Best poster paper award in the Mathematical, Physical, and Engineering Sciences Division.

compounds were cytotoxic to human colon tumor (HCT 116) cells and to starfish fertilized eggs undergoing mitosis. They were subsequently shown to inhibit DNA topoisomerase II in cell-based and cell-free gel assays, thus making them potential anticancer agents.

Four pairs of regioisomers, belonging to the structural class of adociaquinones and xestoquinones, were isolated. Previously known metabolites, adociaquinone A and B, which are 1,1-dioxo-1, 4-thiazine ring derivatives of xestoquinone, a furan-containing pentacyclic quinone, were isolated. Their novel free acid derivatives, secoadociaquinones A and B; and two other pairs of regioisomers, 14-methoxy- and 15-methoxy-xestoquinone, and 15-chloro-14-hydroxy- and 14-chloro-15-hydroxy-xestoquinone, were isolated pure or as inseparable mixtures. The various 1D and 2D NMR spectroscopic methods used to elucidate these structures will be presented here.

## **MICROBIAL DECONTAMINATION OF DEHYDRATED VEGETABLE PRODUCTS USING GAMMA RADIATION**

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The microbial quality of the commercial dehydrated vegetable products, namely, carrots, bell pepper, parsley, tomatoes, and chives, packaged in locally available materials, was evaluated.

Irradiation has been proven capable of reducing microbial contamination in dehydrated vegetable products commonly used in the food industry. A minimum dose of 6.0 kGy could reduce the microbial load of the products by as much as 2-3 log cycles for the total plate counts and 1-2 log cycles for total mold and yeast counts. There were no coliforms detected in the irradiated samples; however, non-irradiated samples showed counts of 4 MPN/g to 1,000 MPN/g.

The results of this study confirm the efficacy of gamma radiation in improving the hygienic quality of various dehydrated vegetable products.

## CAST: COMPUTER ALGORITHM FOR SUBSYSTEMS TEST

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Given any finite algebraic system  $\langle G; O \rangle$  of order  $n$ , an  $n \times n$  matrix  $S(G)$ , known as the structure matrix of  $G$  may be constructed representing the multiplication table of the system. The system is said to be closed if for each element  $a$  and  $b$  in  $G$ , the product  $a Ob$  is again in  $G$ . Hence,  $S(G)$  is said to be closed if all the entries in  $S(G)$  are elements of  $G$ . A subset of  $P$  of  $G$  is said to be a subsystem of  $\langle G; O \rangle$  if  $\langle P; O \rangle$  is closed. Therefore, all the entries of the structure matrix  $S(P)$  must be found in  $P$ .

CAST (Computer Algorithm for Subsystem Test) is a program in PASCAL developed to determine and evaluate (as to types of algebraic system) all subsystems of any given algebraic system  $\langle G; O \rangle$  of order  $n$  where the system is represented by its structure matrix  $S(G)$ . The algorithms used are based on the concepts of ordered trees, Characteristic Pattern Analysis, and the triple product test for associativity of  $O$ .

## THE PHYSICOCHEMICAL AND ANTIMICROBIAL PROPERTIES OF THE TOTAL ALKALOIDS FROM THE BARK OF KAKAWATI [*Gliricidia sepium* (JACQ.) KUNTH ex WALP., FAMILY FABACEAE]

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This investigation on the physicochemical and antimicrobial properties of the total alkaloids from the bark of kakawati was undertaken in order to contribute to the self-sufficiency program of the Philippines relative to developing natural products.

This study deals with the determination of the physicochemical and antimicrobial properties of the total alkaloids from the bark of kakawati [*Gliricidia sepium* (Jacq.) Kunth ex Walp., Family Fabaceae].

**DETERMINATION OF SOME PHYSIOCOCHEMICAL  
AND BIOCHEMICAL FACTORS IN MUNGBEAN  
(*Vigna radiata*) AND RICEBEAN (*V. umbellata*)  
ASSOCIATED WITH BRUCHID RESISTANCE**

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Mungbean [*Vigna radiata* (L.) Wilczek] is a very important legume in Asia, including the Philippines, while ricebean (*V. umbellata*) is an underutilized legume with good potential as food. These legumes serve as a major source of dietary protein specially of the resource-poor. Whereas bruchid (*Callosobruchus chinensis* L.) is a major mungbean storage pest, there is no known commercial variety of mungbean which is resistant to it. Ricebean is known to be generally resistant to bruchid. This study is a part of our project which aims to provide understanding of the biochemical basis for bruchid resistance in mungbean and ricebean.

Initial bioassay experiments using seed meals of mungbean and ricebean accessions revealed that 3 mungbean (Acc. 19, 179, and 214) and 3 ricebean (Acc. 26, 46, and PROC 1) genotypes showed anti-bruchid activity. The albumin fractions of Acc. 19, 179, 214, and PROC 1 were also shown to have anti-bruchid activity by artificial seed bioassay. Polyphenol content, trypsin inhibitor activity, hemagglutinating activity, alpha-amylase inhibitor activity, alkaloid and saponin content were also analyzed. However, none of these anti-nutritional factors were found to be high enough to serve as resistance factors against bruchid in these legumes. Seeds of the resistant ricebean accessions were found to be harder than the susceptible Pag-asa 7. The highly resistant *Vigna radiata* ssp. *subalata*, TC 1996, gave the lowest seed hardness value of 3.2 kg. Current experiments involve the isolation and purification of the bruchid resistance factor in mungbean and ricebean.

## **RELATIONSHIP BETWEEN HEATING VALUE AND CHEMICAL COMPOSITION OF SELECTED AGRICULTURAL AND FOREST BIOMASS**

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Characterization of fuel properties such as heating value, ultimate elemental composition, and proximate chemical composition of agricultural and forest waste is an essential step in the design and evaluation of combustion and gasification systems. This paper presents the results of determination of the above properties of 16 biomass samples which have high potential for use in agricultural applications of process heat from combustors and gasifiers. Conventional prediction equations and regression models were used to estimate the gross heating values of the samples.

The results showed that conventional prediction equations gave a fair estimation of gross heating values. Regressions models with the ultimate elemental composition as independent variables gave better correlation to measured gross heating value than those based on the proximate chemical composition.

## **SIGNIFICANCE OF THE DIFFERENTIAL REC ASSAY AS A PRELIMINARY SCREEN FOR CYTOTOXIC, MUTAGENIC, AND ANTIMUTAGENIC AGENTS**

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Extracts from marine organisms were screened for mutagenic, cytotoxic, and potential antimutagenic activity using the differential rec assay with *B. subtilis* (pour plate method). It was found that the effects of a sample on the activity of the mutagen quinoline can be quantified using as a measure of relative change the percent difference between the zone of inhibition due to the sample plus quinoline and the zone of inhibition due to quinoline alone. For each sample the relative change in the rec strain in M45 can be compared to the change in the rec<sup>+</sup> strain H17 to give clues to the mode of action of the sample.



In this study, we propose that relative changes in inhibition zones cover many kinds of data, each being interpreted of a general mode of action. These possible observations and how they might be used to distinguish among general cytotoxicity, mutagenicity, and antimutagenicity are considered in this paper. Preliminary data from a screening of over fifty sponge and *Conus* sp. extracts are provided and grouped according to the proposed interpretations.

**THE ISOLATION, CHARACTERIZATION, AND  
IDENTIFICATION OF THE ANTITERMITIC  
COMPONENTS OF KAKAWATI  
[*Gliricidia sepium* (JACQ.) STEUD.]**

**ALFREDO R. RABENA**  
*University of Northern Philippines*  
*Vigan, 2700 Ilocos Sur*

Kakawati (*Gliricidia sepium*) also known as madre de cacao, matarraton, bunga Jepun, and Mexican lilac, is a medium-sized tree abundantly growing in the countryside of the tropics particularly the Philippines. Kakawati has been tested on many indigenous applications such as antitick, antimicrobial, and antibacterial. It has been developed for such uses for it is readily available in household gardens.

*Gliricidia* leaves yield crude extracts which contain potential antitermitic substances as shown by bioactivity tests.

It is the main objective of this study to isolate, characterize, and identify new compounds from kakawati leaves and to test these compounds for activity against termites.

**CONSTRUCTION OF LIP- AND RIP-PSEUDOGROUPS  
ORDER  $n=2m$  BY COSET PRODUCT METHOD**

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*Polytechnic University of the Philippines*  
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A simple and direct procedure of constructing a Left Inverse Property (LIP) *pseudogroup* is introduced using the coset product method. Given the cyclic group  $(C_2;0)$  or order 2 and a multi  $\Phi$  system  $(C;\Phi)$  of order  $(m:4)$  where

$$(C; \Phi) = \begin{cases} \text{the group } (C; \phi_{ab}) \text{ whenever } a = 1, b = 1 \\ \text{the group } (C; \phi_{ab}) \text{ whenever } a = 2, b = 2 \end{cases}$$

and  $\Phi = \{ \phi_{11}, \phi_{12}, \phi_{21}, \phi_{22}, \}$ ,  $\phi_{11} = \phi_{12}, \phi_{21} \neq$  and  $\phi_{22}$ , and  $\phi_{11} \neq \phi_{22}$ , then their coset product  $(P; O) = (C_2; O) \times (C; \Phi)$  of order  $n = 2m$  is a LIP pseudogroup. Similarly, a Right Inverse Property (RIP) pseudogroup can be constructed by redefining  $\Phi$  such that

$$(C; \Phi) = \begin{cases} \text{the group } (C; \phi_{ab}) \text{ whenever } a = 1, 2, b = 1 \\ \text{the group } (C; \phi_{ab}) \text{ whenever } a = 1, 2, b = 2 \end{cases}$$

and  $\Phi = \{ \phi_{11}, \phi_{12}, \phi_{21}, \phi_{22}, \}$ ,  $\phi_{11} = \phi_{21}, \phi_{12} =$  and  $\phi_{22}$ , and  $\phi_{11} \neq \phi_{22}$ .

## ON LATIN SQUARES GENERATION AND QUASIGROUPS SYSTEM EVALUATION

AUREA Z. ROSAL and ALLAN L. DIMANLIG

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*Polytechnic University of the Philippines*

*Sta. Mesa Street, Sampaloc, 1904 Manila*

A Latin square is a square matrix of order  $n$  in which each row and each column are permutations of the elements of a finite set  $S$  of order  $n$ . Every Latin square can be regarded as the Cayley table of a quasigroup and conversely. The number  $L_n$  of Latin squares of order  $n$  has the following lower bound:  $L_n \geq n! (n-1)! \dots 1!$ . Using this formula therefore, there are at list 288 Latin squares of order 4 and 34,560 Latin squares of order 5.

A computer program written in Turbo Pascal for Latin squares generation, known as I Construct is developed to generate all Latin squares of any given order and the same may be evaluated as to the type of mathematical system they repreent. Quasigroups such as loops, invertible loops, pseudogroups, and groups, either abelian or non-abelian can be constructed using simple commands. Any two quasigroup tables generated may also be tested for isomorphism.

I construct is a very effective tool currently being used by the researchers of the Mathematics Research Group of the PUP SCITECH R&D CENTER for generating examples of quasigroups of any given order for investigation.

## COMPARISON OF THE RAPID FIELD TECHNIQUE WITH CONVENTIONAL METHOD FOR PESTICIDE RESIDUE DETECTION

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Rapid techniques for pesticide residue detection were developed and compared with gas chromatographic analysis.

The rapid field kit for organophosphate insecticides is specific for compounds of the organophosphorus type (e.g., monocrotophos, chlorpyrifos), with a detection limit of as low as 0.01  $\mu\text{g}$ . The technique can be done in 4 steps within 3 minutes. The kit costs nine hundred fifty pesos which can accommodate three hundred analyses (equivalent to PhP 3.17 per sample) This technique is one thousand times cheaper than the conventional method.

For carbamates (e.g., carbaryl and carbofuran) and organophosphates, a rapid field kit was packaged utilizing an enzyme inhibition technique. It can analyze two types of pesticides at one time in about 10 minutes. It is very sensitive, with a detection limit of as low as 0.20  $\mu\text{g}$ . It is very economical: an analysis would cost only two pesos. The kit costs about five hundred pesos and can accommodate 250 samples.

For pyrethroids (deltamethrin and cypermethrin) and organochlorines (DDT), a micro TLC set was packaged into a rapid field kit. It is quite sensitive with a detection limit of as low as 0.05  $\mu\text{g}$ . The kit costs about three thousand pesos and can accommodate about the three hundred samples (equivalent to PhP 10 per sample).

The conventional gas chromatographic analysis requires sophisticated equipment and voluminous extracting solvents. One analysis costs three thousand pesos. This method is highly sensitive but analysis is tedious and time consuming. This would however be a good complementary check with the rapid field techniques.

The rapid field kits can be used in screening pesticide residues in the field and results can be obtained immediately so that recommendations to farmers can be made which, if followed, would lead to the reduction of pesticide residues.

The Codex maximum residue limits in most agricultural crops range from 0.01 mg/kg to 5 mg/kg. This is the range detected by the rapid test kits.

## ***SOCIAL SCIENCES DIVISION***

### **MULTICULTURAL PERSPECTIVES IN EDUCATION FOR SUSTAINABLE DEVELOPMENT\***

**DANIEL S. SANTOS**

*Pamantasan ng Lungsod ng Maynila  
Intramuros, 1002 Manila*

Experts in multicultural education define multiculturalism as referring to demographic, socio-economic, ethnic, religious, etc. differences that allow its application in all counselling relationships and processes. It is addressed to the issues of equity, designing appropriate services, and assisting teachers with educational curricular and instructional development. Using content analysis and interview as research methodologies in 1995, the author studied the multicultural education programs/services provided at Faith Academy, Brent School of Manila, International School of Manila, and Arizona State University to promote multicultural understanding. The educational programs/services identified that promote multicultural understanding and educational development are: scouting program, band and choir, Chinese Cultural Club, French Club, International Club, Model United Nations, Philippine Cultural Club, Spanish Club, Achieving a College Education, Summer Connection, Navajo Summer Institute, Success, Academically Talented Program, Students Taking Action to Reach Success, Movimiento Estudiantil Chicano de Aztlan, Native American Students United, STEP Honor Society, Asian Coalition, Women of Color, and Intergroup Relations Theater Troupe. At Arizona State University, the Minority Assistance Program (MAP) was created to provide minority students with academic and personal support. The MAP office seeks to help students better understand the environment in which they learn. Recommended components for multicultural classrooms, instructional methods for cross-cultural education, and curriculum guidelines for multi-cultural education are highlighted in the study.

\*Best poster paper award in the Social Sciences Division.



## APPENDICES

### A. GUIDELINES FOR TECHNICAL PAPER PRESENTORS

1. The original and two copies of the manuscript (including illustrations) should be sent to

Miss Luningning E. Samarita  
Executive Director  
National Academy of Science and Technology, Philippines  
2/F Philippine Science Heritage Center, DOST Complex  
Bicutan, Taguig, 1631 Metro Manila

2. Manuscript text, tables, references, footnotes, and legends must be computer-printed in size 12 points (not less than 0.3 cm in height for capital letters) on one side of opaque paper, 22 x 28 cm, double-space throughout, and with at least 4 cm margins all around. All manuscripts must be dark, clear, and of letter-quality.
3. The first page should include title, author(s), and affiliation(s). Names of all authors should be given in full. In coauthored manuscripts, designate with an asterisk the author to whom correspondence should be addressed. A single paragraph abstract is required, preferably directly under the author's affiliation. The abstract should be followed immediately by a list of approximately 10 key words suitable for information retrieval systems.
4. Illustrations should be of high quality, original, inked line drawings, or glossy photographic prints. Lettering should be sans serif, with consistency of size and thickness of line appropriate to the size and complexity of the drawing after reduction. Authors should anticipate that capital letters and numbers may be as small as 1.5 mm high after reduction. Half-tones and color illustrations may be included only when deemed to be necessary. Brief but adequate legends for the illustrations should appear together on a separate page.
5. Tables should be numbered in one consecutive series of Arabic numerals and should be referenced by number in the text. Each table should be placed on a separate sheet of paper with the table number and fully descriptive title at the top. The top of tables and illustrations printed in the landscape orientation should be on the left for easy reading.
6. The author-year documentation system should be followed. References are cited in the text, in parentheses, by author's last name (no comma after the name) and the year of publication. These references are listed alphabetically, with full bibliographic information, at the end of the text. An essential general guide to style and format is the latest (1993; 14th) edition of **The Chicago Manual of Style** published by the University of Chicago Press, 5801 Ellis Avenue, 4th Floor, Chicago, IL 60637, USA. An indispensable reference in the physical sciences and mathematics, as well as in the life sciences, is the latest (1994; 6th) edition of **Scientific Style and Format: The CBE Manual**

for Authors, Editors, and Publishers in the Biological Sciences published by the Council of Biology Editors, Inc., 11 South LaSalle Street, Suite 1400, Chicago, IL 60603, USA.

7. The use of the latest edition of **Webster's Third New International Dictionary of the English Language Unabridged**, (with Seven Language Dictionary), published by Encyclopædia Britannica, Inc., Chicago, in three volumes, is strongly recommended.

**B. GUIDELINES FOR TECHNICAL PAPER WRITERS**  
(See also **GUIDELINES FOR TECHNICAL PAPER PRESENTORS**)

I. TITLE, AUTHOR(S), AFFILIATION(S)

- a. TITLE: All caps; center; bf; 14 pts.
- b. TITLE INCLUDING A SCIENTIFIC NAME: All caps except scientific name, genus and species names cap and lc, ital; name of taxonomist cap and small caps; center; bf; 14 pts.

**ULTRASTRUCTURAL CHANGES IN THE DIGESTIVE SYSTEM  
OF *Achatina fulica* FERUSSAC  
INDUCED BY THE MOLLUSCICIDE BAYLUSCIDE**

- c. ONE AUTHOR WITH ONE AFFILIATION:  
AUTHOR'S NAME: In full; normal order; all caps; center; 12 pts.  
AFFILIATION: Caps and lc; center; ital; 10 pts.

**METAZOAN PARASITES OF SOME FISHES  
FROM TAALLAKE**

**NELLIE C. LOPEZ**  
*Institute of Biology, College of Science*  
*University of the Philippines Diliman*  
*1101 Quezon City*

[NOTE: The ZIP Code number should be written on the left-hand side of the last line of the address, preceding the name of the city, municipality, or province. --- The Zip Code Directory of the Philippines, Philippine Postal Corporation.]

d. **TWO OR MORE AUTHORS WITH ONE AFFILIATION:** All names in full; normal order; three or more names are separated by commas; a comma precedes "and"; all caps except "and"; center; 12 pts.

**VARIABILITY IN RESPONSE  
OF SELECTED RICES TO TUNGRO**

CESAR G. DEMAYO and ISAIAS T. DOMINGO  
*International Rice Research Institute  
College, 4031 Laguna*

e. **TWO OR MORE AUTHORS WITH DIFFERENT AFFILIATIONS:** Affiliations are indicated separately for each author; identified respectively by superscript Arabic numbers.

e-1. Philippine affiliations:

**A DENJOY-TYPE INTEGRAL  
FOR BANACH-VALUED FUNCTIONS**

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e-2. Philippine and foreign affiliations:

**A MEASUREMENT OF STRESS RELAXATION FOR STUDYING  
RICE ROOT RESPONSE TO SALINITY**

PHILBERT S. BONILLA<sup>1</sup> and MIKIO TSUSHIYA<sup>2</sup>  
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3119 Nueva Ecija*  
<sup>2</sup>*Okayama University, Tsushi ma-naka 1-1-1  
Okayama, Japan*



e-3. U.S. affiliations:

**BIOASSAY OF NATURALLY OCCURRING ALLELOCHEMICALS  
FOR PHYTOTOXICITY**

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<sup>2</sup>*Department of Biology  
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U.S.A.*

[NOTE: The ZIP Code number in the U.S. is placed after the name of the state. For purposes of the TRANSACTIONS, the name of the state is spelled out.]

2. ABSTRACT: One paragraph (not more than 150 words) is required, directly under the author's(s) affiliation(s).

3. KEY WORDS: Approximately 10 words for information retrieval systems.

4. TEXT:

MAIN TOPICS – Center, 12 pts, all caps, bf.

Subtopics – Flush left, 10 pts, caps and lc, bf, no punctuation.

Sub-subtopics – Indent 5 spaces, 10 pts, caps and lc, ital, dash.

5. REFERENCES:

Arrange alphabetically according to the last name of the senior author.

Give full bibliographic data:

a. Journal articles: Names of all authors (include first names of lady authors in full), year of publication, complete title of article (capitalize only the first letters of the first word and proper nouns), conventional abbreviation of journal title in italics (no punctuation after the title unless the last word is an abbreviation which needs a period), volume, number of issue in parentheses, colon, inclusive pagination. (Lists of recommended abbreviations of journal titles are printed in *Chemical Abstracts* and *Index Medicus*. Titles of less well-known journals are best spelled out.)

Raymundo, Assuncion K., and J. A. Leach. 1993. Amplification and sequence analysis of the upstream region of the *hrpXa* gene homolog in *Xanthomonas oryzae* pv. *oryzicola*. *The Philippine Journal of Biotechnology* 4(1):24-38.

Rimando, Agnes M., J. M. Pezzuto, N. R. Farnsworth, T. Santisuk, V. Reutrakul, and Kazuko Kawanishi. 1994. New lignans from *Anogeissus acuminata* with HIV-1 reverse transcriptase inhibitory activity. *J. Nat. Prod.* 57(7):896-904.

Sia, I. C., L. G. Velayo, Felicidad C. Mateo, Patricia A. Sunga, and E. de los Santos. 1993. Parmakolohiya sa komunidad: Mga nakatagong gamot sa mga bahay sa Barangay Bongo, Gapan, Nueva Ecija. *Acta Medica Philippina* 29(3):161-168

b. Books: Names of all authors (include first names of lady authors in full), year of copyright, complete title of the book (capitalize the first letters of all important words), edition if other than the first, publisher, city (include state or country only if the city is not widely known).

Barrion, A. T., and J. A. Litsinger. 1995. *Riceland Spiders of South and Southeast Asia*. The University Press, Cambridge.

Ladrado-Ignacio, Lourdes, and A. P. Perlas. 1994. *From Victims to Survivors: Psychosocial Intervention in Disaster Management*. University of the Philippines Manila, Manila.

c. Chapters or other titled parts of a book or papers in published proceedings: Names of all authors (include first names of lady authors in full), year of publication, complete title of the chapter/paper (capitalize only the first letters of the first word and of proper nouns), period. In (capital I), colon, name(s) of editor(s), complete title of the book (include edition, if other than the first) or of the proceedings (capitalize the first letters of all important words), publisher, city (include state or country only if the city is not widely known), inclusive pagination.

Jolliffe, Georgina H., and G. O. Jolliffe. 1993. The computer as an aid in the identification of powdered vegetable drugs. In: *Trends in Traditional Medicine Research, Proceedings of the International Conference on the Use of Traditional Medicine and Natural Products in Health Care, 8-11 June 1993, The School of Pharmaceutical Sciences, University of Science Malaysia, Penang*, pp. 71-77.

Walden, R. 1993. Cell culture, transformation, and gene technology. In: Lea, P. J., and R. C. Leegood, eds., *Plant Biochemistry and Molecular Biology*, John Wiley & Sons, Chichester, England, pp. 275-295.

d. Special cases: Multivolume works, series, multivolume work within a series, no ascertainable publication data, unpublished material, etc. Consult the references recommended in Appendix A, Guidelines for Technical Paper Presentors.

## 6. CHARACTERS/SYMBOLS:

Characters/symbols (chemical, multilingual, mathematical, scientific, Greek, etc.) should be clearly computer-printed – never handwritten.

### C. GUIDELINES FOR POSTER ABSTRACT WRITERS

1. Title, author(s), affiliation(s)

(See also GUIDELINES FOR TECHNICAL PAPER WRITERS)

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University of the Philippines Diliman (U.P. Diliman, UPD)

University of the Philippines Manila (U.P. Manila, UPM)

University of the Philippines Los Baños (U.P. Los Baños, UPLB)

University of the Philippines Visayas (U.P. Visayas, UPV)

University of the Philippines Open University (U.P. Open University, UPOU)

University of the Philippines Mindanao (U.P. Mindanao, UPMin)

2. Abstracts should include the following:
  - a. Background of the study (identify the gap in knowledge of the subject and what is to be done to fill this gap)
  - b. Methodology, using terms understandable by the majority
  - c. Valid scientific name, family, common name, and part(s) used in studies dealing with plants
  - d. Results so far obtained at the time of writing
  - e. Significance of the results, if the study has been completed.
3. Abstracts should be followed by not more than 10 key words for information retrieval purposes.
4. Abstracts should be typed double-spaced, in size 12 points (approximately 0.3 cm in height for capital letters), on one side of opaque paper, 22 x 28 cm, with at least 4 cm margins around, and the type must be clear and of letter quality.

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